TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XI, No. 6. JUNE, 1934. PRICE 6d.

CONTENTS.

	PAGE.
Cacao Research	129
The Oil Palm in Sumatra	131
Principles of Banana Breeding	132
The Banana Leaf Disease in Surinam	138
Protection against Yellow Fever	142
Banana Diseases	143
Reviews	149
Impressions of the Cacao Industry of Grenada	151
Crop Products Manufacture	152
College Sugar Factory	153
Sugar Notes	154
Chemical Notes	155
Market Notes	156

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

CACAO RESEARCH.

THE officers of the Cacao Research Scheme, have just presented their Third Report * which deals with the progress of their activities during 1933. The Scheme, to which reference † has already been made in these columns, has had as its main objects the improvement both of the yield and quality of plantation cacao, and it is becoming increasingly evident that since its inception much new ground has been covered in a comparatively little known field of research.

The present Report follows closely on the lines of those which have been previously issued. The first part is devoted to the botanical and the second to the chemical and ecological aspects of cacao research.

The botanical section includes physiological and genetical studies. In the former, attention has been paid mainly to the problems of vegetative propagation of cacao continuing the use of soft wood cuttings and layers as the most practical methods. On the theoretical side of this work interesting light is being shed on the inter-relation of different phases of meristematic activity at the ends of cuttings, so that the problem of why some cuttings form callus readily but do not root, whereas others root quickly without very much callus development may be approaching a general explanation. Cacao can be considered, when conditions are favourable, to be an easy plant to root from cuttings, but the conditions are narrowly defined and slight divergence from them results in failure. On the practical side the bulking up of sufficient vegetatively propagated material from selected trees to plant up a large scale experiment is the immediate work in hand, and from the time the experiment is planted, physiological work will be centred on the detailed comparison of growth and performance of the different clones and types of root stocks, clonal and seedling. In the absence of any previous data regarding the properties of a satisfactory root stock in cacao, trees of surpassing vigour and proved heavy cropping capacity have been selected for this purpose and are now being

* Third Annual Report on Cacao Research, 1933, 72 pp. and 3 plates, 4 diagrams. Price 5s. To be obtained from the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

† Cacao Research. *Tropical Agriculture*, Vol. X, No. 8, pp. 209-211.

propagated. From rooted cuttings, nursery layers are being prepared which are expected to provide an abundant supply of vigorous material in the future.

In the genetical studies results of experiments to the end of 1933 are described which fall under the headings of (*a*) provision of better planting material and (*b*) the method of treatment of this material. Under the first heading it is shown how the work of previous years, during which a genetic analysis of the cacao crops was made, can be utilized as a basis for the selection of desirable types for future planting, not only in Trinidad but also in all other producing countries. The suggestion is put forward that the intrinsic yielding capacities of the main cultivated types are probably not very different although there is no doubt that environment plays a major rôle in deciding which types will thrive best in any locality. Thus, for successful planting, the type most suited to the environment must first be decided upon. Then, from the selected type, the highest yielding trees must again be picked out and by this means potential yield in Trinidad of twenty or thirty hundredweights of superior beans per acre are shown to be not improbable.

Under the second heading it is shown that the practice of vegetative propagation in cacao, besides preserving uniformity of type does increase the uniformity of yield from tree to tree. It is demonstrated, moreover, that the type of rootstock used in budding methods may have a profound effect on the quantity as well as the quality of the produce of the scion.

In continuation of previous studies of the factors affecting fruitfulness in cacao, a manurial experiment has been laid down from which information is expected on the effect of nutrients on the general health of the tree and consequently on fruit setting and maturation. The nutrient effect may be expected to become increasingly pronounced in the cacao field of the future, in which high yielding types on highly efficient rootstocks will increase the drain on limited soil resources, and the experiment has thus a bearing upon the selection programme as well as upon immediate yields. Finally as an aid to selecting types of high intrinsic quality as shown by the absence of pigment in the beans a study has been made of the relation between the presence of pigment in different parts of the plant. From the results obtained it actually appears that the colouration of pods and young leaves provide very little guidance as to the quality of the beans produced.

The main lines of work during 1933 of the Chemical and Ecological Section have consisted in the completion and publication of results of a detailed soil survey of some 80 square miles of cacao land in the Montserrat District of Trinidad; the reaping and the statistical analysis of yield data of field experiments with phosphate and potash manures, based on the findings of soil surveys; the chemical analysis of leaf material obtained from cacao trees growing on the experimental manurial plots, in an attempt to assess the nutrient requirements of cacao by means of leaf analysis; and a critical examination of meteorological data collected during a three years' period at two contrasted "good" and "bad" sites growing cacao under estate conditions, and (for comparison) at the College Meteorological Station, The present stage reached in each of these investigations is described.

As a result of soil surveys of three different cacao growing areas in the British West Indies, a number of conclusions are presented regarding the physical and chemical characteristics of good cacao soils. It has been concluded that there is a lack of balance in the nutrient status of low yielding soils, phosphate in particular being deficient while nitrogen appears to be adequate. Hence beneficial results cannot be expected for manuring cacao with arbitrary nitrogen, phosphorus and potassium mixtures. Although the cacao soils of these regions are derived from entirely different parent rock materials, the better-yielding soils of each are sharply contrasted with the poor-yielding soils in respect mainly of content of available phosphate, and the carbon-nitrogen ratio of their organic matter component. These fundamental differences have suggested *specific* manurial experiments, from which it has been possible to show that plots receiving different dressings of superphosphate manure have given increases in yield of the order of 50 per cent. during the first crop after the application of the manures. The yield data have also provided useful information concerning the technique of laying-out manurial experiments on cacao.

In a general study of "nutrient balance" between the three elements, nitrogen, phosphorus and potassium, consideration has been given to the results of recent researches on the mineral nutrition of fruit trees conducted in England, the United States of America and elsewhere, with a view to their possible application to problems concerning the growth and manuring of the cacao tree. Thus, the results of the chemical analysis of young cacao leaves collected from plots receiving different manurial treatments, have been interpreted in the light of modern theories concerning physiological balance in plant nutrition. By selecting as a standard of comparison the chemical composition of cacao leaves taken from high-yielding trees growing on a soil of high natural fertility, the effect of different manurial treatments on the trees has been assessed. Thus, for instance, if a manurial treatment has altered the chemical composition of the leaf so that the proportionate amounts of the different elements approach closer to the standard values, then it has been concluded that the particular manurial treatment has resulted in an improved balance in the supply of mineral nutrients. Chemical analysis of cacao leaves taken from a field manurial experiment have shown that phosphate manuring has resulted in a more balanced nutrient supply, but that very

heavy dressings of superphosphate appear to have resulted in unbalanced nutrition unless potash also is applied. These findings coincide with the yield responses obtained from this manurial trial. It has been demonstrated here that the greatest increase in yield was obtained from moderately heavy dressings of superphosphate.

The application of phosphatic manures alone resulted in increasing the proportion of potash to nitrogen in the leaf. Potash manures alone did not have such a marked effect on the relative proportion of nitrogen to potassium in the leaf, which indicates that the cacao tree may be unable to obtain adequate supplies of potassium when phosphate is deficient. This finding may have an important bearing on the problem of Thrips attack on cacao, since previous investigations have shown that cacao trees possessing a high ratio of nitrogen to potassium in the leaf are particularly susceptible to attack

These preliminary results suggest that leaf ash analysis furnishes a means of diagnosing nutrient deficiencies and nutrient requirements that may render possible the more exact interpretation of manurial experiments, and the formulation of balanced manurial mixtures for application to the cacao tree under different conditions of soil and environment.

A detailed statistical examination of the inter-relationships that exist between various atmospheric factors which are involved in the evaporation of water from soil and plant concludes the chemical section of the Report. By the collection of data on the subject it is hoped to guide the ecological investigator in his detailed studies of plant environments and to give greater definition to problems concerning the effects of wind belts, shelter belts and shade trees.

The Cacao Research Scheme was financed for five years in the first instance, a period which terminates in September, 1935. Its future will depend in a large measure on the continuation of the support which it is at present receiving from certain British cacao producing colonies and British cocoa manufacturers. It is obvious that the investigations undertaken have al eady yielded results of practical usefulness and it is not unreasonable to anticipate that further important discoveries are likely to be made which should benefit both planters and manufacturers. It is earnestly to be hoped therefore that continued support will not only be given to the scheme by those already contributing towards its expenses but that help will also be forthcoming from other quarters which may benefit from improvements in the supply of cacao.

THE OIL PALM IN SUMATRA.

Notes on the Oil Palm on the east coast of Sumatra.

THIS is a long and very complete account by J. E. Opsomer (*Bulletin Agricole du Congo Belge*, XXIII, 1932) of the cultivation of the oil palm in Sumatra. The palm is fairly accommodating as to soil but develops best on deep, flat alluvial, sandy loam or volcanic soils having a high pH content. Perfect drainage is essential. The optimum climatic conditions are abundant rainfall (by night if possible), a high light intensity and a mean temperature of 24 to 26°C. The palm fruits best with an average humidity of 50 to 70 per cent. It resents dry winds, but, its pollen being wind borne, air movement is necessary for its effective pollination. Propagation is effected by sowing selected seed in the open without shade, in specially prepared soil. Germination is slow when the seed is not fresh and it is customary to stimulate it in various ways. (1) Soaking in water for a period of six or seven days. The temperature of the water when the nuts are first put in is 45-50°C., it is subsequently allowed to cool naturally. This system gives a 50 per cent. germination in three months and 80 per cent. in six months. (2) Soaking in a one per cent. solution of hydrochloric acid for two days, followed by a 3-days' rinsing in running water. This gives 85 per cent. germination in nine months. It is said, however, that seeds sown the same day as gathered will give equally good results. The seedlings are transplanted into nurseries (situated on the plantations to reduce transport) where, spaced 18 inches apart they are kept for a year. In the plantation the planting distance is about 30 feet.

Various leguminous cover crops are used. The trees are regularly manured with organic manure. Chemical manuring is still in the experimental stage. The local pests and diseases are briefly mentioned and there is a chapter on the manufacture of the oil. Research is proceeding in the following directions:—Improvement of varieties by cross pollination and selection. The pollen is collected, dried and distributed over the female flowers with a glass and rubber dusting apparatus. It can be preserved dry in good condition for nine weeks. Artificial pollination as a cultural practice has been provisionally abandoned. In the first year it will give an increase of 80 per cent., but the second year only 20 per cent. The trees, moreover, are thought to suffer, there is an excessive fruit drop, and the size of the fruits is said to diminish. It is thought, however, that some modified system of artificial pollination in conjunction with manuring for instance, on rich ground only, or at certain times of the year, might prove advantageous and experiments are in progress. Experiments on the hastening of germination and manurial trials are also being carried out, most of them as in this case being undertaken by the Algemeen Proefstation der Algemeene Vereeniging Van Rubberplanters der Oostkust van Sumatra (usually known as A.V.R.O.S.).—(*Horticultural Abstracts*, Vol. III, No. 2, Ab. 246.)

PRINCIPLES OF BANANA BREEDING.

By E. E. Cheesman, M.Sc., A.R.C.S.,
Professor of Botany in the Imperial College of Tropical Agriculture.

Introduction.

Experiments in banana breeding have been carried on at the Imperial College of Tropical Agriculture since its inception as the West Indian Agricultural College in 1922. Some results were published in a Progress Report issued by the Empire Marketing Board in 1931 (14) and others, more specialised in nature, appeared in 1932 (16,17). Towards the end of 1932, however, the various items of information collected along several lines of enquiry began to fit together and present a picture of the problem as a whole such as had previously been lacking. As one consequence the programme was at that time revised in the light of knowledge gained and put upon a less empirical basis. As another, the definite stage reached provided a convenient point for a fuller survey of the work than had previously been presented. The fact that such a stage was attained by coincidence just ten years from the commencement of the researches enables a survey to function also as a report on a completed decade of investigation, and the author hopes that this publication may be found apposite in both connections.

Some repetition from the earlier publications has been unavoidable. The progress report of 1931 was based on less than half the data now presented, and many of its tentative conclusions need correction in the light of later knowledge. Its figures have therefore been incorporated, together with as much of the subject matter as was necessary to make the present account complete in itself. On the other hand the historical presentation there adopted has been rejected, and for details of the inception and earlier stages of the researches, for which the present writer was not responsible, reference should be made to the paper in question (14). Similarly it has not been thought necessary to repeat the notes on the very simple technique of pollination which were formerly given. From the cytological papers (16, 17) little has been borrowed except chromosome numbers, and for fuller details of cytological phenomena reference may be made to the journal cited.

The Economic Aspect.

The researches which form the basis of this discussion began with a defined problem in plant breeding, and have been directed throughout by economic considerations.

The problem set in 1922, and still awaiting complete solution, is to breed a new banana combining all the good commercial qualities of the existing Gros Michel variety with resistance to Banana Wilt, commonly called Panama Disease. In compactness of bunch, the possession of a skin not abnormally sensitive to bruising, ability to stand up well to conditions of bulk transport and attractive appearance on ripening, the Gros Michel or Jamaica banana is almost ideally suited to the extensive fruit trade that has been built upon it. Unfortunately it is highly susceptible to the attacks of the fungus *Fusarium cubense* E. F. Smith, and the resultant Panama Disease has for some years been a serious factor in banana production for export in the West Indies and Central America. By analogy with other wilt diseases, and with other maladies similarly caused by micro-organisms that can live in the soil for long periods in the absence of their usual plant hosts, it appears that the ultimate control of Panama Disease is most likely to lie in the substitution of a banana variety immune or highly resistant to attack. Varieties are known which show resistance to a degree constituting immunity for practical purposes, but none of them has yet proved entirely suitable to replace Gros Michel, hence the need for attempts to build up the required genotype by plant breeding methods.

This problem presents in its most acute form a difficulty that in varying degree is common to much fruit-breeding work. The greater part of the value of a commercial banana depends upon the fact that as usually grown it is completely seedless. The fruit develops parthenocarpically and the sexual organs are abortive to an extent usually exceeding 99 per cent. It is therefore necessary in breeding from commercial bananas, first to induce them to set seed, which has happened to prove relatively easy, and later to learn how to re-induce sterility among the offspring, which has proved much more difficult and still needs more study.

In view of such a complication, it was from a very early stage apparent that investigations restricted to a narrow range of breeding material might prove unprofitable, and as knowledge has accumulated it has become increasingly clear that scarcely any information that can be acquired about the genus *Musa* is without some bearing on the central problem. A collection of banana varieties has been formed, primarily with a view to ascertaining whether any are possible substitutes for Gros Michel in large scale cultivation, but also with the idea that some of them may prove more suitable than that variety as breeding material. The collection has brought its own subsidiary problems of identification and classification. Wild and fertile species of *Musa* have likewise been collected as essential to the breeding operations, and have introduced taxonomic questions. By no means least, investigations of chromosome number have proved essential in the search for a key to the study of sterility.

Thus the work has of necessity broadened, as investigations in applied biology are apt to do, until it includes much beyond its original scope. It has acquired a significance wider than the

Panama Disease issue, and that issue must tend to be obscured in the general discussion of the following pages. This survey has been entitled "Principles of Banana Breeding" because most of the findings are equally applicable to any other banana breeding programme. Such a programme might at any time be rendered necessary by a new disease, increased severity of a known one, or agricultural considerations quite apart from pathology. The essential achievement of the period under review has been the establishment of guiding principles which enable banana breeding to be conducted by methods rather better than the pure y empirical. At the same time it is to be emphasised that solution of the Panama Disease problem remains in fact the immediate goal, and that the complications of the programme are not divergent side lines followed for their academic interest, but convergent main lines of attack.

The Genus *Musa* L.

The genus *Musa* L. is a fairly large one, the *Index Kewensis* with its supplements listing 134 speci ic names. The actual number of valid species known possibly lies between 60 and 70, and there is evidence that others remain undescribed. Fortunately the interests of the banana breeder appear to lie within a narrower range, and it is in this connection that the taxonomy of the genus has an important bearing on the breeding problem.

The standard treatise on the genus is that of J. G. Baker published in 1893 (9), upon which all subsequent accounts have been based. Baker recognized 32 species, and following a less formal treatment by Sagot (54) grouped them into three sub-genera, defined as follows:—

Physocaulis.—Stem bottle shaped. Flowers many to a bract. Petal usually tricuspidate. Fruit not edible. (7 spp.).

Rhodochlamys.—Stem cylindrical. Flowers few to a bract. Petal linear. Fruit usually not edible. Bracts brightly coloured, often red. (11 spp.)

Eumusa.—Stem cylindrical. Flowers many to a bract. Petal ovate-acuminate. Bracts green, brown, or dull violet. Fruit usually edible. (14 spp.)

This classification is in the main sound, for there are definitely three distinct groups which might perhaps be raised to generic rank with advantage. Baker's key characters, however, seem open to improvement, and in several cases the writer would refer species to sub-genera other than those under which Baker has placed them. The writer's experience has admittedly been limited to about two dozen species, but with those his attention has by the nature of his main interest been forcibly directed to the seed. He has found that all the seeds yet examined fall into three quite distinct groups, and when the species are classified according to their seed-type the divisions correspond fairly closely to Baker's sub-genera. *Physocaulis* species have more or less globose seeds, usually smooth, commonly half an inch or more in diameter, with a deeply sunken hilum; *Rhodochlamys* species have sub-clyindrical or obpyriform seeds, with a large air space occupying the dorsal half, which is marked externally by a transverse ring and a difference in surface markings between the upper and lower halves; *Eumusa* seeds are more or less flattened dorsiventrally, typically very irregularly angled and commonly tubercled, rarely as much as half an inch in diameter. It is tentatively suggested that these differences between the seed types are more fundamental than most of Baker's key characters, and might be substituted in the division of the genus. Unfortunately, in many original descriptions of species which have not been seen in Trinidad, the notes on the seeds are inadequate, and pending examination of herbarium material the usefulness of the seed character cannot be tested on the genus as a whole. In two cases where its use necessitates a change of sub-genus there can be little doubt that the species concerned are brought into a more logical position judged on the sum of their characters. *M. glauca* Roxb. is transferred from *Eumusa* to *Physocaulis*, where it belongs on the majority even of Baker's criteria, and *M. ornata* Roxb. is transferred from *Rhodochlamys* to *Eumusa*, with other members of which it shows more points of similarity than of difference.

Many new species have been described since 1893, and a revision of the genus is required. The present work may in time bring together enough material for revision to be carried out, but it will require a much larger collection of species than is yet available. For the practical purposes of the present work 154 published specific names have been tentatively referred after study of the available literature to headings as follows:

Physocaulis	34
Rhodochlamys	13
Eumusa	19
Generally accepted as synonyms	29
Edible bananas given Latin binomials	34
Species dubiae	25
	154

The members of sub-genus *Physocaulis* are almost entirely African in distribution, although *M. superba* Roxb. is ndian and *M. glauca* Roxb. ranges wild and presumably indigenous as far East as the Philippine Islands (57). They are in general characterised by their pseudostems being swollen at the base, and by an absence of vegetative offsets, the whole plant dying after flowering. Their whole habit is distinct from that of any cultivated edible banana, and it is difficult to imagine that they can have contributed anything to the crop as it exists. Therefore for economic work, where it is essential that the field of investigation be narrowed down in some degree, they can apparently be neglected without any serious risk of loss.

The sub-genus *Rhodochlamys* needs further study. On available evidence it seems to be the least natural of Baker's groups, and there is reason to expect that several of its species should be transferred to *Eumusa*. *M. assamica* Mann, *M. aurantiaca* Mann, *M. Mannii* Wendl., and *M. sanguinea* Hook. f. are all said to be closely allied, and the affinities of *M. sanguinea* at least would appear to be with *M. ornata* Roxb. rather than with the remaining members of *Rhodochlamys*. The sub-genus, as thus emended, would on present evidence seem unlikely to have contributed to the banana complex, but our knowledge of it is too fragmentary for any definite pronouncement.

The main interests of the banana breeder are thus narrowed down to the twenty species or so which constitute the sub-genus *Eumusa*. All the banana varieties with edible fruits appear to be derived from this group, not excluding "*M. maculata*", the exact identity of which is uncertain, but which seems to have been placed in *Rhodochlamys* on account of a misunderstanding of Jacquin's illustration (*Hort. Schoenbr. t.* 446). All varieties yet induced to seed have yielded typical *Eumusa* seeds, and on the working hypothesis that they are descended either from existing wild species or from extinct forms very closely allied, their study demands a detailed survey of this section.

The Imperial College collection contains at present nine or ten distinct *Eumusa* species, but owing to the time taken in getting them together, only four of them have figured in the breeding programme of the period under review. The most interesting fact which has emerged from the species collection to date is that two species (of which we have 13 and 8 varieties respectively) are outstandingly common and widely distributed. It is natural to conjecture that the importance of these two in connection with banana problems may be commensurate with their frequency, though the conjecture may be dangerous unless used with reserve. Both are well-marked in their major characters, but yet very variable within themselves, so that they must be considered as "Linnean" species which might be almost indefinitely subdivided were there any advantage in the division. In both cases crosses between varieties have proved easy to make and fully fertile.

One of these Linnean species is indigenous in India and Ceylon, extending north to the Himalayas and south and east as far as Java and the Philippines. It includes *M. sapientum* of the "Flora of British India" and of Kurz, *M. paradisiaca* of Trimen's "Flora of Ceylon", *M. brachycarpa* Backer in "Flora van Java" and *M. errans var. Botoan* of Teodoro in the Philippines. It is almost certainly to be identified with *M. alphurica* of Rumphius. There are a number of seedless edible clones which appear on all grounds to be derived from this wild species, and they are all among the coarser bananas, commonly used cooked. *M. sapientum* Linn. if defined by the cited figure in Trew (*Ehret. Pl. Select. Tab. XXI*) belongs quite definitely to this affinity. It will probably never be known exactly which variety of banana was Linnaeus's type, indeed he seems to have based his *M. sapientum* on several forms not closely related. His name, however, was applied to the seeded plant by Roxburgh, and coupled with a fairly full description by that botanist (*Fl. Ind.* 663). It is therefore convenient to employ for the wild species the designation *M. sapientum* Linn. *sensu* Roxb.

The other species or species-group of exceptional frequency is common and often abundant in the appropriate ecological habitats throughout the Malay Peninsula and Archipelago. This has not been reported from India or Ceylon, nor yet from the Philippines, and the extent of its range eastward remains to be determined. It includes *M. simiarum* of Rumphius and in part of Kurz, *M. malaccensis* Ridley and *M. zebrina* Van Houtte. Its correct name seems to be *M. acuminata* Colla, although the fact that Colla described his species as "seedless" (apparently in error and possibly from observation of an unpollinated inflorescence) has caused considerable confusion in the nomenclature. Backer in "Flora van Java" describes *M. zebrina* as occurring in a great number of forms, which might be considered as species, were they not connected by all transitions. Observation of the Imperial College collection of eight clones from Java and Malaya and elsewhere, and of crosses between some of them, bears out Backer's statement. Two extreme varieties might be selected from our material as distinct species, but the other six provide transitional forms.

The possibility has been suggested by Kurz (40), Ridley (52) and Backer (7) that some of the edible bananas of Malaya and the East Indies owe their origin wholly or in part to *M. acuminata*. So far as the majority of varieties of commercial promise, including Gros Michel, are concerned, this suggestion is far more plausible than the supposition that they have anything whatever to do with *M. sapientum*. The bulk of dessert bananas differ from the latter species in almost every character, but agree in many respects with *M. acuminata*.

In the present state of knowledge only the barest speculations can be advanced concerning the relationships of the banana complex, but there are at least four possibilities being kept in mind which have a certain amount of evidence to support them and may be mentioned quite tentatively. They are: (i) That several of the coarser bananas of no interest to the export trade are derived wholly or mainly from *M. sapientum* L. *sensu* Roxb. (ii) That several of the dessert bananas of the Gros Michel class, including Gros Michel itself, have been derived from *M. acuminata* Colla, with or without admixture of other more localised and less well known species of Malaya, Siam or Indo-China. (iii) That certain Indian varieties of possible commercial potentialities owe their origin in part to species received by us from Northern India but not yet identified. (iv) That many of the bananas most characteristic of the South Sea islands owe their origin largely to some species of that region not yet identified, this last assumption

being based on the observation that according to descriptions they exhibit features quite opposed to those of either *M. sapientum* or *M. acuminata*.

There is abundant evidence in the very modest collection of species brought together in Trinidad to date to show that taxonomic studies of *Eumusa* have very definite contributions to make to banana breeding problems, and the economic advantages which might accrue from a really comprehensive collection of *Eumusa* species are very great.

The Varietal Problem.

The survey and arrangement of edible banana varieties available as potential breeding material are at least as difficult as the actual breeding itself, and scarcely less important if the work is to follow any logical plan. Some consideration must therefore be devoted to the varietal problem in its relation to the wider problem of crop improvement.

The term "edible bananas" serves as a simple inclusive designation of the members of the genus *Musa* cultivated for their fruit. Normally they are seedless and are propagated by vegetative offshoots, so that the precise term "clone" is applicable to each of the established kinds, and may be used in preference to the looser term "variety" or alternatively with it. It is true that between completely sterile and parthenocarpic forms on the one hand and fully fertile seeded species on the other certain intergrades occur, the edibility of which may be a matter of personal opinion or circumstances, but such are not common or important enough to cause any serious confusion.

The old controversy as to what constitutes a *banana* and what a *plantain* is easily and justifiably settled by using one word to cover both. In parts of the East, "plantain" serves the dual purpose, but "banana" is chosen here as being more generally familiar. The distinction, when made, is not a botanical one and has never been better defined than by the statement that a banana is suitable to be eaten raw and a plantain is not palatable until cooked. We even find this given in a standard systematic work as the distinction between *M. sapientum* and *M. paradisiaca*, to which "species" the two classes of fruit are commonly assigned. The distinction has of course a genetic basis, since it depends upon the relative proportions of starch and sugars in the ripe fruit, but the differences may well be varietal rather than specific, like similar differences, for example, in maize and in peas.

Mention of the "species" *M. sapientum* (*sensu lato*) and *M. paradisiaca* introduces the first step which is necessary to clarification of the varietal problem, namely the rejection of all Latin binomials applied to edible clone . They serve little or no useful purpose, and their misuse has done much to confuse the study of the genus. Some authorities regard *M. sapientum* as a sub-species of *M. paradisiaca*, and others prefer to rank *M. paradisiaca* as a sub-species of *M. sapientum*, whilst still others treat them as two distinct species and force every edible *Musa* as a variety into one or the other according to the culinary distinction mentioned above. From *Species Plantarum* (*Ed. 2.* 1477) it is clear enough what Linnaeus meant by *Musa paradisiaca*. His description is simply "Musa spadice nutante, floribus masculis persistentibus" but this, together with his citation of Trew *Ehret. Pl. S lect. t.* 18 is sufficient to fix his type among the few bananas which have persistent male flowers. It is perhaps the commonest of the "plantains", and although it possibly contains several sub-varieties differing only in minor respects, it is sufficiently well marked off from the majority of varieties to be easily distinguishable. On the other hand, its actual relationship to other varieties cannot at present be determined. With *Musa sapientum* the case is otherwise. The description "Musa spadice nutante, floribus masculis deciduis" affords no help at all, and the citations indicate that Linnaeus had in mind several varieties not really closely related. Trew *Ehret. Pl. Select. t.* 21 is a plant undoubtedly related to what was called in the foregoing section *M. sapientum* Linn. *sensu* Roxb., but other illustrations cited do not appear to belong to the same affinity at all. Thus *M. sapientum* Linn. *sensu lato* as an indication of relationship is practically meaningless.

Another binominal in common use is *M. Cavendishii*, applied to the widely distributed Dwarf Banana, *M. sinensis*, *M. chinensis* and *M. nana* being used in the same sense. The Dwarf happens to be so distinct in appearance that no confusion has hitherto arisen, but it has recently been shown (20) that at least one tall banana variety appears so closely related to the Dwarf that if a specific name is to be used for the one it should logically be extended to the other. As the tall variety in question, though very distinct in physiological and genetical behaviour from Gros Michel, could not on any criteria usually adopted by the systematist be specifically separated from that clone, it follows that the Dwarf is linked by intergrading forms with more than one tall variety, and the possibilities of confusion, if *M. Cavendishii* is to be admitted as a possible specific name for tall bananas as well as for the dwarf form, are boundless.

Besides these three in universal use there are, as noted in a foregoing section, some thirty or more binomials confusing the nomenclature of the genus, almost all of them associated with the barest and most inadequate descriptions. When, if ever, the genetic origins of the edible bananas have been discovered, formal specific names may possibly be applicable to them with advantage, but for the present the use of such combinations does nothing but create confusion and is strongly to be deprecated.

The second step in clarification of the varietal problem is frank recognition of the fact that no classification of edible bananas is possible at all until much more study has been devoted to diagnosis of varieties. This opinion is supported by Teodoro, who in his "Preliminary Study of Philippine Bananas" (57) writes: "So far as cultivated musas are concerned, a monograph must be of little value when the vast majority of

apparently distinct varieties are still botanically unknown, and when the named varieties, and even species, are so incompletely known and described tha they are often totally unrecognizable among their very numerous congeners . . . Attempts to classify the species of *Musa* supposed to include the cultivated varieties, without this study of all the varieties, leads only to uncertainty and confusion." C. A. Backer also remarks: "The definitive systematic arrangement of the numberless Javanese culture-forms, including undoubtedly many introduced from elsewhere, can only be done, if it is possible at all, by someone who can occupy himself with the subject for a very considerable time—it is a lifetime's task. Not only the cultivated but also the wild forms of the whole of Asia and Polynesia would have to be introduced and studied on living material, since herbarium material consists only of small and very misformed fragments and the works which have hitherto appeared are all highly incomplete." (*Flora van Java*, Pt. 3, p. 138., present writer's translation).

The varietal problem is thus reduced for immediate discussion to the problem of identification, and the difficulties of identification depend firstly on the inordinate number of varietal names in use and secondly on the nature of the plants themselves, which is by no means well suited to varietal diagnosis.

The number of varietal names in use probably runs into several thousands. In the course of these studies some attempt was made to compile a complete index of those which have actually appeared in print. Seven hundred entries were made in the course of a few weeks of intermittent reading, and it then became doubtful whether a list three times as long would be anywhere near complete. The idea was abandoned for the time being, because its usefulness did not appear commensurate with the labour involved, but the experience gained from the attempt had a definite value for the light which it threw on the state of affairs prevailing in banana nomenclature. It was clear that, as might be expected, the prime cause of the multiplicity of names is simply language. So wide is the distribution of the crop that the number of languages and dialects spoken over even its native range is quite possibly greater than the number of varieties extant. To these are added the languages of all the countries of introduction, and the application of new local names even in districts where introduction is comparatively recent. Different European writers list Eastern native names according to different systems of spelling, and although the connection is often obvious the cases are not few in which a reader without knowledge of the language concerned is in doubt whether the names are synonymous or not. Further complications are introduced by mistakes which are very apt to occur when foreign names are copied on labels and records in countries of introduction.

It need scarcely be added that only fresh confusion is created if a student at a distance from the country concerned assumes identity of names which look or sound alike without further evidence. As an example of the influence of dialect and spelling systems the Horn plantain is outstanding. What is almost certainly the same variety appears variously in the literature as *Tando, Tandoc, Tandock, Tandok, Tandon, Tanroe, Tindoc, Tindok, Tondoc, Tondok, Tundoc,* and *Tundok* besides having numerous synonyms from different roots, whilst *Tudoc, Tuldoc,* and *Tumoc* of the Philippines are not to be confused with the same variety, being quite distinct. As an example of what is probably a pure mistake in copying a label may be mentioned the variety *Coolie Honkseng* which appears in one list (dated 1928) as an introduction from the Philippines. Reference to Barrett's list of introduced varieties in the Philippines (11) dated 1913 reveals a variety called *Coolie* obtained from Hong Kong, and the coincidence is, to say the least, suggestive.

Complexities of varietal nomenclature are by no means peculiar to the bananas, and they have been dwelt upon only because the writer inclines to believe that the diversity of this crop may perhaps have been somewhat exaggerated in the past. Almost all writers on the subject stress the profusion of varieties, but it may be borne in mind that an impression of great diversity might be as easily derived from a hundred distinct varieties as from a thousand, especially when formed by a travelling observer seeing bananas under widely different conditions in different countries and inevitably biassed by the number of different names given to them.

More critical evidence is afforded by the published lists of observers who have intensively studied the varieties of their own countries, and no such list exceeds a hundred entries unless it admittedly includes synonyms. In view of the very extensive introduction from country to country which is recorded for recent times and seems to have occurred also in the more remote past, it may be fairly stated that there is no direct evidence of the existence of more than a hundred banana varieties in all.

Publications from the Philippine Islands are specially interesting in this connection, because that region is relatively near the centre of distribution and at the same time more careful descriptive work has been done there than in most countries. Barrett (11) in 1913 formed a collection of 159 local and 95 introduced kinds, but his list admittedly contained synonyms. Teodoro (57) in 1915 carefully described about 27, and Quisumbing (50) in 1919 extended Teodoro's studies to 60. Mendiola (43) in 1926 stated "There are no less than 67 edible varieties of Musa in the Philippines"—a figure strikingly near to Blanco's earlier estimate (13) in 1877 of 57.

For Malaya, Hale (29) lists about eighty different names, and does not suppose that his table contains more than half the names that could be collected. His notes, however, are preliminary, and no comparisons were completed between the "varieties" collected. There is little reason

to doubt that this list contains many synonyms. Milsum (45) gives a list "obtained through the courtesy of the Chief Agricultural Inspector, Federated Malay States, who instructed the Malay Assistants and Sub-Inspectors in the different States to forward a list, with any information available, of those banana varieties known to them". This list contains 34 names, and Milsum considers that though small "it most probably includes the majority of varieties of value".

In India, according to the Kew Bulletin of 1894, Roxburgh obtained only three varieties of the "plantain" and about 30 of the "banana". Jogiraju (35) has recently listed 36 names from Northern Madras, of which he notes 15 as synonyms of others and one as a seeded type, leaving 20 representing distinct varieties.

For Hawaii, Pope (48) describes 17 native and 17 introduced varieties, many of the latter being the common and widely distributed types of other countries.

The United Fruit Company's collection at Almirante, Panama, described by White (63) in 1928 as "probably the most complete in the world to-day" consisted at that time of approximately two hundred clones "many of them very closely allied, or even duplicate, strains coming from different regions of the earth and passing under different names".

Further evidence tending in the same direction is afforded by the varietal studies reported in the next section.

Some reliable estimate of the number of varieties extant would be of direct economic advantage. That taxonomic confusion causes serious wastage of effort and money in scientific work cannot be disputed. One example in illustration will suffice. Bananas known in various countries as Lacatan, Bumulan, and Giant Fig have all attracted considerable attention as possible substitutes for Gros Michel in large scale cultivation, since they are resistant to Panama Disease and show many good commercial features. Similar research work has been duplicated on each, but when they were brought together in one plot they proved to be identical (20). At the same time Pisang Masak Hijau of Malaya was shown to be another name for the same banana, and it may be hoped that the identification will save a further replication of investigations on the Malayan stock.

It is clear that the extent to which hopes may be entertained of a reduction of the present confusion depends very largely on the number of varieties to be collected, described and ultimately classified. If that number should prove to be manageably small (say two or three hundred) then efforts to achieve complete codification would be economically justified. All that can be said in the present state of knowledge is that the most generous estimate based on published lists does not exceed three hundred and fifty, even ignoring the strong indications that quite a number of varieties are common to nearly all banana growing countries.

The difficulties introduced into diagnosis by the nature of the plants themselves are of two kinds. In the first place, bananas do not lend themselves to the preparation of dried herbarium material, and the various other methods of preserving type specimens are not only cumbrous but also inadequate, largely because they destroy colour, which is often a very important diagnostic character. The differences between varieties are also frequently so slight that they must be lost in any preserved material, however carefully treated. In some of the most difficult cases, which happen at the same time to be the most important economically, the essential differences are almost entirely physiological, and the minor morphological differences which are found on close scrutiny to be correlated with them defy preservation in any dead form. The differences between Gros Michel and Masak Hijau, for example, are of this kind.

The possibility of referring a variety to a preserved standard is still further diminished by the physiological plasticity which bananas exhibit to an extraordinary degree. Differences of environment, not only between countries or districts, but even between different parts of the same field will induce changes of appearance that may mislead quite experienced observers.

There is one satisfactory way of "preserving" a type specimen to overcome these difficulties, and so far as the writer can see only one, namely, to keep it alive by clonal propagation, under conditions of the most rigid control with respect to labelling that can be devised. Just as identifications of more amenable plants are in the last appeal referred to type herbarium specimens, so the final appeal with edible bananas must lie in growing them side by side with living type specimens.

For diagnosis with slightly less precision, the most useful "material" would appear to be accurate colour drawings, and failing those, photographs judiciously chosen to bring out the most important diagnostic features. Verbal descriptions alone are almost useless, but suitably illustrated descriptions aid materially in the advance of knowledge. Yet from the best of descriptions identity cannot be finally established without comparison of living material.

The steps by which alone it appears possible to make a serious attack on the varietal problem are, first the careful comparison of "varieties" in each banana growing country and reduction of the names in use to a single set of "standards" to be employed in all local scientific work, secondly the comparison of local "standards" from different countries on a central station which can define and maintain "type specimens" in a living condition.

Note. The full list of references will appear at the end of the series.

(*To be concluded.*)

THE BANANA LEAF DISEASE IN SURINAM.

By Gerold Stahel,
(*Agricultural Experiment Station, Surinam.*)

Introduction.

In the experimental fields of Congo bananas on eight different estates, planted under the auspices of the Surinam Agricultural Society in 1931 and 1932, a leaf disease appeared during 1933.

The two most vigorous and healthy looking fields suffered first. One of them lies in the Surinam, the other in the Commewijne district. In the Surinam field the disease was first noticed in April at the beginning of a heavy rainy season, on the Commewijne field in October during a normal dry period. In both fields the soil consists of a low but well drained clay, which especially in the Surinam field contains a high amount of humus.

The soil of the Surinam field is very acid (pH 4.2) with much soluble aluminum (344 mgr. $Al_2O_3 + Fe_2O_3$ per litre drainage water) according to analyses and further observations made by Dr. H. J. Müller, the Chemist of the Agricultural Experiment Station and Chairman of the Banana-Committee of the Agricultural Society. Poisoning by aluminum might possibly explain the bad condition of this field.

In the Commewijne field the pH value is normal (5.0). Here the shallow layer of topsoil, which easily dries up in the dry season, seemed to be responsible for the premature dying and drying-up of the banana leaves.

This opinion seemed to be confirmed, when in the beginning of the rainy season in November sound leaves were formed again. After about five weeks, however, the disease reappeared in a serious degree. Since several months the Surinam field has ceased to produce suitable commercial bunches for export, whereas in the Commewijne field the size of the bunches is reduced.

In November and December, 1933, the disease also appeared in the other six experiment fields, in three of them seriously at the beginning of January, 1934. Here the bananas were planted on normal high plantation clay, which means that the surface of the soil lies about one foot higher above the average water level in the drains than in the first mentioned fields. The supposition that the low clay-soil is in particular responsible for leaf disease, had therefore to be abandoned. Heavy outbreaks are not connected exclusively with this kind of soil.

It is noteworthy that none of the planters who cultivated Congo bananas here on a commercial scale in 1911-1914, can remember having seen this disease in these earlier days.

Will the leaf disease in the banana plantings on the high clay soil take the same disastrous course on low clay land, and will the spraying with Bordeaux mixture prove to be economically applicable? The next years probably will give the answer to these questions.

Most of the bananas in Surinam and all varieties, even *Musa textilis* are now affected in a more or less serious degree. It is, however, most striking that bananas grown under shade trees such as Erythrina are nearly free from the disease. This is particularly conspicuous in fields where bananas grow partially with and without shade trees. Under the shade, healthy normal leaves are formed, whereas in the open part of the plantation the older leaves especially are covered with dry spots.

It remains to be seen from field experiments whether it is possible to check the disease sufficiently under light Erythrina shade without reducing markedly the normal production of bunches.

Leaf Spots and their Fungal Flora.

The appearance of banana leaf spots in Surinam is exactly the same as that described by Ashby, Ogilvie and Wardlaw for the West Indies. In heavily infected fields the youngest leaves may already be affected at the top. On the leaf blade the spots first appear mostly on the second or third leaf. Both, the lenticular spots on the blade and the wedge-shaped marginal lesions are commonly found in Surinam.

Sometimes in badly affected fields the entire blade of the older leaves dies prematurely as a result of the quickly enlarging lesions.

If the dead leaf spots are inspected during rainy weather or after having been for some days in a moist chamber, several fungi constantly are found to be associated with these spots. *Hormodendron cladosporioides* and *Cordana musae* are found commonly and most abundantly. The dead wedge-shaped areas spreading from the margin over the leaf are often covered with a dense and strong, fairly pure growth of *Hormodendron*. On the lenticular spots on the blade, however, if not too old and extended, an abundant development of the conidiophores of *Cordana* can be observed in most cases.

Helminthosporium is less frequent. The black colonies of the fructifications of this fungus were found especially on small spots or sometimes also in the centre of the larger lenticular lesions surrounded by a broad margin of *Cordana* conidiophores. The colonies of *Cordana* have a greyish-brown powdery aspect.

Of other fungi *Nigrospora*, *Fusarium*, *Verticillium*, an Ascomycete with 4-celled dark spores, and several others were found, but less frequently and apparently all growing as saprophytes.

Isolations of Fungi from Young Leaf Spots.

A microscopical examination of young leaf spots showed no hyphae in the yellow-green margin round the brown spots. The water vessels,

however, appeared to be filled in most cases with a brown-red coloured gum, in which neither bacteria nor hyphae could be detected. Close to the dead area, in the centre of the spot, a few brown dead cells were sometimes found amidst the still green palisade tissue. Between these discoloured cells some minute hyaline hyphae of about only one micron diameter could regularly be found.

Attempts were made to isolate the fungus from the margins of leaf spots. The leaf surface was sterilized with alcohol and small pieces placed on nutrient agar, following Wardlaw's method (*Trop. Agriculture*, 1934, p. 13). Some of the inoculated agar tubes remained sterile; the others, however, produced fungi, especially *Cordana*, but also others including *Nigrospora*, *Verticillium*, *Aspergillus* and sterile mycelia. This is entirely in agreement with Wardlaw's experience in Trinidad.

The fact that besides *Cordana* varions other fungi were isolated shows that this method does not give definite information as to the true parasite. Exact infection experiments alone can give a decisive answer to this question.

Only two of the fungi proved to be able to invade the unwounded leaf, namely *Helminthosporium* and *Cordana*.

Infections with Helminthosporium torulosum.

Helminthosporium was isolated from poured agar-plates and cultivated in beakers on sterilised banana leaves, on which medium the fungus sporulates abundantly, without the formation of aerial hyphae commonly produced on nutrient agar (Mango-agar).

From banana leaves, sound pieces of three by three inches were cut and placed, upper surface up, in Petri dishes, both portions being supplied with wet filter papers. In these dishes the leaf pieces remained in a satisfactory condition for eight to ten days.

The conidia were suspended in a small quantity of water and smeared on the leaves with a small soft brush. The surface of the three youngest leaves, however, is so waxy that the water does not adhere, least of all on the youngest leaf. A very thin felt-like piece of moist glass-wool was therefore laid on these leaves. Under this the suspension of conidia spread easily over the leaf surface.

After about one hour in the moist chamber the conidia germinate, and four to six hours later the germ tubes begin to form big appressoria (Fig. 3). With a little experience it is easy to cut tangential pieces of the epidermis, without penetrating deeper into the leaf tissue than the layer of the uncoloured water cells. To do this the leaf piece is bent over the left forefinger.

After 12 hours some of the appressoria have already pierced the cuticle and the outer wall of the epidermis. Before this wall is ruptured the globularly depressed wall forms a lens, which concentrates the light so that a bright disc is visible near the lower surface of the appressorium (Fig. 4).

After the wall has been pierced, the epidermal cell is immediately killed and the contents transformed into a reddish-brown granular substance. Even if an appressorium is accidentally formed just above a stoma the infection tube never enters through the opening but penetrates into the guard cells. The infection tube in the epidermis-cell swells up and grows out into several large globular cells, which fill up the infected cell. The neighbouring cells of the epidermis and also the underlying water cells are then killed in advance of the fungus, indicating the action of diffusing toxic secretions. (Fig. 6).

In cross-sections of a leaf two days after infection with *Helminthosporium* conidia, many of the discoloured dead brownish water cells still appear free from hyphae. The fungus next penetrates to a dead water cell and forms immediately a new globular cell close to the wall. From this large cell several hyphae grow out straight through the water cell to the inner wall, where again appressoria are formed. They also pierce this wall and the infection tube grows right down into the palisade cell to the lower end, where a further appressorium appears (Figs. 7 and 8). Having passed these three layers without intercellular spaces (epidermis, water and palisade tissue) and having crossed directly through the cells the fungus then spreads unimpeded through the intercellular spaces to the cavity in the mesophyll; here it spreads everywhere in the loose mesophyll tissue.

The writer did not investigate whether the partitions of the different cavity compartments, typical of a banana leaf, are penetrated intracelluarly with the aid of appressoria, or whether the fungus can make its way between the killed cells of the partition walls.

In moist Petri dishes, as mentioned above, the five youngest leaves of a banana plant were heavily infected with *Helminthosporium* conidia. When cut, the youngest leaf was still partially rolled. Microscopical inspection of this very young leaf showed 1½ days later, plenty of lesions of the dimensions shown in Fig. 6.

On the four other leaves the lesions were of the same or of a slightly smaller size. After three days the fungus on all five leaves had reached the lower surface of the leaf. On the youngest leaf one single large brown spot appeared of the same size as the infected area on the other side. On the four older leaves this area was spotted with many small stripes of dead tissue.

This experiment was repeated, but this time with the 13 first leaves of a strong banana plant grown on fertile sandsoil. Again on the youngest nearly unfolded leaf the fungus penetrated in three to four days to the lower surface.

On the second to the seventh leaf only a few dead points appeared on the lower leaf-side, but from the eighth up to the thirteenth leaf, large dead brown areas were found on the lower surface of the leaf.

In the field also some series of infection experiments were carried out on Governor bananas. The leaves were infected on the upper side at about two inches distance from the margin in the same manner as described for the infections in the Petri dishes. The infected area was covered with a watch-glass fitted inside with three wet filter papers. A second watch-glass of the same size was placed at exactly the same place against the lower surface. The two glasses were held *in situ* by two small, very light laths made of the wood of a cigar-box. Outside the leaf margin the laths were held together by a strong rubber band. After 1½ or 2 days the glasses were removed.

Consistent results were repeatedly obtained. Three days after infection, brown stripes or bands appeared on the lower surface corresponding with the infected area on the upper side.

A suspension of conidia was also dusted with a sprayer into the narrow funnel of a very young, still entirely unfurled leaf. After inoculation the open end was closed by two laths with rubber bands. After five days the right leaf-side, which bordered the inside of the hole, was very badly affected. At the same time typical black points appeared on the cavity of the midrib. These superficial points commonly found in the field are therefore also caused by *Helminthosporium*.

In the field some full grown leaves were infected with *Helminthosporium* conidia without any special precaution being taken. Especially during clear nights with a heavy formation of dew, these infections were successful but in a far lesser degree than when protected by a moist chamber (a watch-glass) for two days.

In the field, banana leaves affected by very young natural lesions were repeatedly collected and the epidermis inspected microscopically by means of tangential sections. Several times, on the centre of very young brown spots, the infecting appressorium with the completely empty *Helminthosporium* conidium was observed. Only the thin flabby chitinised exosporium was left (Fig. 6).

Thus *Helminthosporium* is an active parasite which can easily penetrate the epidermis of an unwounded leaf provided the conidium lies long enough and undisturbed in a thin layer of water.

Infections with Cordana musae.

Cordana was also isolated from agar poured-plates. On agar, however, the production of conidia is retarded and never abundant. The conidia grow here more roundish than on the natural substratum. On sterilised banana leaves the fungus grows very slowly. For infection experiments therefore conidia were obtained from the lower surface of leaf spots kept in a moist chamber. Under these conditions *Cordana* sporulates profusely. Before a spot was selected to furnish the conidia for an infection experiment, it was carefully inspected with a strong hand lens for the presence of *Helminthosporium* conidia in the centre. The *Helminthosporium* colonies look black and a little granular, whereas *Cordana* covers the lesions with a grey-brownish powdery growth. All spots with *Helminthosporium* were excluded.

The fructifications of other fungi such as *Hormodendron, Fusarium, Nigrospora,* &c., are not troublesome in these experiments. The germ tubes of these fungi never pierced the epidermis, nor did they enter the stomata of living banana leaves.

Most infection experiments were carried out together with *Helminthosporium* as parallel experiments.

Disseminated on the leaf surface and placed under a moist bell-jar, the two-celled *Cordana* conidia germinate with but few exceptions from the proximal pointed cell on the sidewall near the septum, never at the pointed end. After about eight hours the comparatively short germ tube forms a dark appressorium, which several hours later drives an infection tube into the underlaying epidermal cell; here one or more large globular cells are formed, which fill up nearly the whole of the cell, just as with *Helminthosporium*. In living leaves the contents of the appressoria apparently are transferred entirely into the epidermal cells. The emptied appressoria collapse. The epidermal cell, however, is not killed immediately as with *Helminthosporium*. The infection tube can be seen in the epidermal cell before the contents are discoloured. But when this tube begins to swell up, the whole interior of the cell colours yellow at once (Figs. 11, 12 and 13).

In the same way *Cordana* easily enters dead leaf spots. Here the large globular fungus cells in the epidermis, evidently for a great part also the product of the mycelium in the inner leaf-tissues, pierce the epidermis wall from the inside, forming on the surface of the deal leaf large round cells, which grow out to conidiophores with the typical basal bulb (Figs. 10 and 15).

On the living leaf pieces in moist Petri dishes as mentioned under *Helminthosporium*, the fungus penetrated into the inner leaf tissues only on the first very young leaf, which was not entirely unfolded when cut. It reached the lower surface in about three days, producing there a large brown spot. On all other leaves up to the thirteenth *Cordana* entered easily the epidermal cells. But then the layer of large living water cells proved to be an unsurmountable barrier for this fungus.

The infections in the field under watch-glasses had a similar result, but the effect on the youngest leaf was less conspicuous.

In the older leaves the contents of the epidermal cells infected by *Cordana* colour from yellow, through brown to pink; *Helminthosporium*, on the other hand, gives a bright brown-red.

If an intact full-grown leaf infected with *Cordana* is inspected with a strong hand lens the surface looks mottled with minute black spots. These spots are formed by the epidermis cells which are invaded by *Cordana*.

General Remarks about the Banana Leaf Disease.

The study of the development of the two fungi *Helminthosporium torulosum* and *Cordana musae* shows that both are responsible for the trouble caused by the banana leaf disease.

The first is a powerful parasite able to pierce not only the living epidermis but also to enter through the layer of large water cells into the inner leaf tissues, killing immediately all the cells it reaches on its way. The large water cells are killed in advance before the fungus enters them.

Cordana, on the other hand, has inferior qualities as an attacker of the unwounded full-grown leaf. This fungus pierces the epidermal wall of the living leaf if continually moistened during about 12 hours, and fills up the epidermal cells with large globular fungus cells. It is, however, not able to kill the large water cells by poisonous secretions as does *Helminthosporium* and therefore cannot enter the inner tissues of the leaf.

Probably *Cordana* can live in the epidermal cells in the form of the large globular hyphae for a long time. These hyphae enter the inner leaf tissues at the moment that the leaf tissue dies at this point. The fungus therefore has an advantage over other fungi, which first have to pierce the epidermal wall of the dead leaf spot. *Helminthosporium* was only detected on small leaf spots or on more extended lesions in the centre surrounded by a growth of *Cordana*. Small leaf pieces from the margins of the bigger lenticular spots commonly yielded on nutrient agar the mycelium of *Cordana*.

The conclusion therefore seems sufficiently founded that *Helminthosporium* makes the breach in the healthy unwounded banana leaf. After some time, however, the *Helminthosporium* mycelium in the leaf spot is entirely overgrown by *Cordana*, which after the barrier of living water tissue has been killed, can penetrate into the inner leaf, where it plays the part of an active secondary parasite. *Cordana* then takes over the functions from *Helminthosporium* and penetrates inside the two layers of water cells into the living mesophyll.

To enter the banana leaf *Cordana* is probably able to use also the breaches in the water tissue, which have been made by other fungi or other agents.

A successful infection depends in the first instance on an uninterrupted moist leaf surface during at least 10 to 12 hours, as it happens here with the formation of dew in clear nights on open fields. Under shade trees the formation of dew is prevented or greatly diminished with the result that bananas growing under shade are practically free from the leaf disease as already stated.

The mode of infection of the South American Hevea leaf disease is an exactly corresponding case. About 18 years ago the rubber plantations in Surinam were destroyed by this leaf disease, but all the rubber trees accidentally grown under shade trees such as Erythrina, produced leaves permanently free from the disease.

With both diseases, the banana and the rubber leaf disease, the fungus enters the leaf not through the stomata, but through the cuticle by means of appressoria. To enter the leaf the first germinated conidia need at least 10 to 12 hours. After the infection tubes have pierced the cuticle the further development of the two fungi however is very different.

It is most interesting that the behaviour of both diseases is entirely different in Trinidad and in Surinam. In Trinidad the trouble caused by the Hevea and banana leaf disease is insignificant. In Surinam, however, exactly the same diseases proved to be destructive even to such a degree, that the rubber culture had to be abandoned entirely, whereas the prospects for the commercial cultivation of Congo bananas, though immune to the Panama disease, are uncertain at this moment.

Evidently the average time during which the leaves are covered with dew is somewhat longer in the dampish lowland of Surinam, than in the hilly country of Trinidad. A covering of dew remaining only half an hour longer on the leaves is already sufficient to give a chance to a great number of the earliest appressoria to pierce the epidermal wall, which otherwise would have dried up and died during the day.

Heavy rains are not favourable for this kind of disease. The conidia are washed away and the moist condition of the leaf surface frequently does not last long enough. Clear nights during the rainy season, however, are very suitable for the spreading of these diseases, owing to the heavy formation of dew.

Eventually it is possible that the soil and the climate of Surinam produce banana plants with a slightly thinner cuticle and weaker cell walls so that the epidermal wall can be pierced in the same time by more infection tubes than elsewhere under the same outside conditions.

Description of the Illustrations.

FIGS. 1-8. *Helminthosporium torulosum.*

FIGS. 9-16. *Cordana musae.*

Index to Illustrations.

1. Conidium of *Helminthosporium* with the thin chitinised exosporium and the thick endosporium.

2. A young conidiophore with conidium.

3. A germinated conidium with appressorium.

4. A germinated conidium with two germ tubes, each with an appressorium. One has already pierced the wall of an epidermal cell. The infection tube of the other has not yet ruptured the cell wall, but is visible in the lower appressorium as a bright disc. The endosporium walls of the germinated conidium are already dissolved partially.

5. The infection tube has penetrated the cuticle but not yet ruptured the wall of the epidermal cell.

6. Very young natural lesion on a leaf collected in the field. Five epidermal cells and one water cell are already killed. In the first cell entered, two (or three) dark globular fungal cells are seen. The infection hypha entered a second epidermal cell. This hypha soon will swell up to typical globular cells. The empty flabby exosporium of the germinated *Helminthosporium* conidium is still attached to the collapsed appressorium by the germ tube.

7. Part of a water cell with infection hyphae of *Helminthosporium*. The contents of the epidermal cells were not clearly visible in this section. The large fungal cell close to the epidermis has produced five hyphae, which have grown straight to the inner wall, where appressoria are formed.

8. Hypha of *H. torulosum* in the palisade parenchyma.

9. Cross-section through a dead leaf spot. *Cordana* mycelium in the tissue and globular cells in the epidermis. On the left young globular cells, still hyaline and evidently just formed by appressoria, which must have been rubbed away during the preparation of the section.

10. Outgrowing hyphae of *Cordana* which will form conidiophores.

11. A germinated *Cordana* conidium with a short germ tube and an appressorium.

12. An appressorium with a short infection tube. The contents of the epidermal cell are not yet discoloured.

13. A *Cordana* appressorium with a germ tube, which has already formed globular cells. Note the dead granular contents of the epidermal cell.

14. Infection hyphae of *Cordana* in a very young, partly unfolded banana leaf. In the upper part the hyphae in the water cell are producing small appressoria on the inner wall. Two hyphae have entered a palisade cell, again forming appressoria in the lower part of the cell.

15. Globular cells of *Cordana* inside and outside the epidermis of the underside of a dead leaf spot. The cell outside the cuticle is evidently just formed from inside and represents therefore a young conidiophore, not an appressorium.

16. An epidermal cell of a very young leaf with three globular *Cordana* hyphae. One has pierced the wall to the water cell and has formed another globular fungal cell, wherefrom several hyphae will arise later and grow to the inner wall of the water cell as seen in Fig 14.

All drawings were made with the aid of a Zeiss Camera Lucida (×725), *except Fig.* 5 (×1700).

PROTECTION AGAINST YELLOW FEVER.

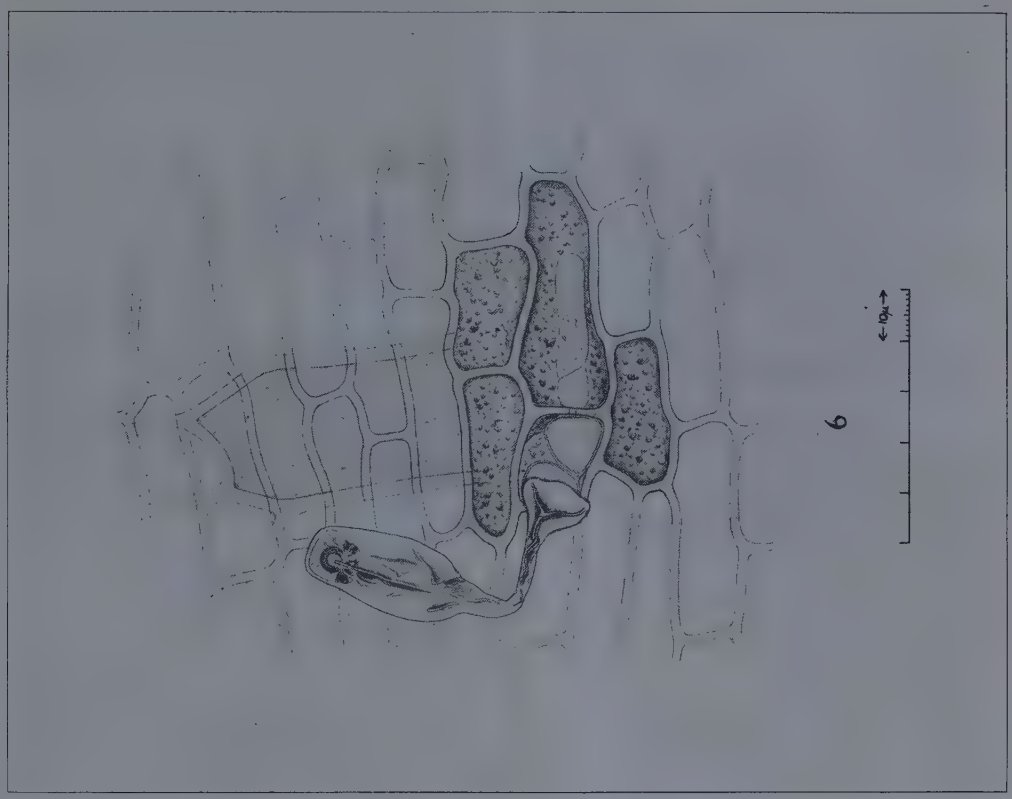
(*Abstracted from "Nature," No.* 3338, *p.* 628.).

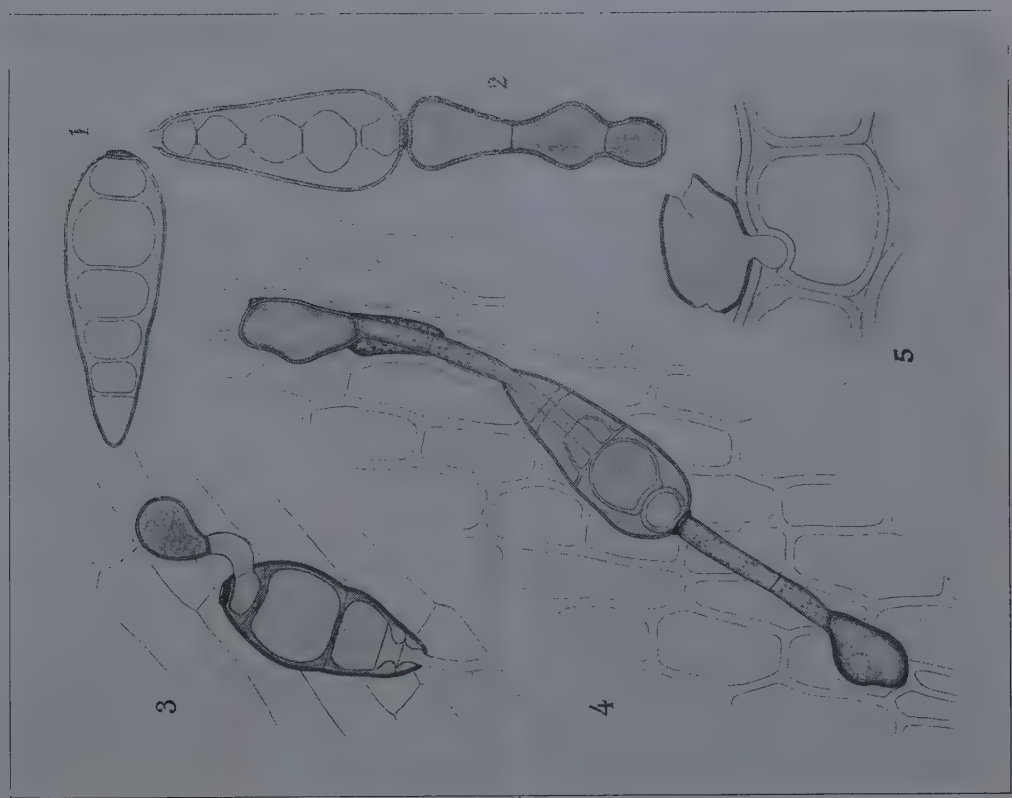
For some time research work on yellow fever was handicapped by the fact that the ordinary laboratory animals are not susceptible to the disease. However, in 1927, Stokes, Bauer and Hudson found that certain species of Asiatic monkeys could readily be infected, and this gave the work a new lease of life. In a remarkably short time methods of immunisation have been developed in spite of serious difficulties, and it is probable that the latest advances have practically cleared the path for safe and complete protection against the disease.

Hindle showed that when the yellow fever virus is exposed to the action of various agents such as formaldehyde, or phenol and glycerine, or simply kept exposed to air, it gradually loses its virulence. It then passes through a phase when its inoculation into susceptible animals is followed by the development of immunity without any clinical signs of infection. This seemed to have solved the problem, and the method was used with success by Aragao in the yellow fever epidemic of Rio de Janeiro in 1928. But Hindle had also showed that continued exposure of the virus to the attenuating agency (formaldehyde, phenol and glycerine or air) ultimately caused disappearance of all protective power, and the difficulty lay in estimating the exact degree of modification necessary to convert the virus into a vaccine. This difficulty was overcome when Theiler discovered in 1930 that by successive inoculation into the brains of mice the yellow fever virus loses to a great extent its power of producing a general infection in man or monkeys. This so-called "mouse virus", if injected subcutaneously in extremely small doses, generally fails to produce any serious reaction, but the inoculation is followed by the development of immunity approximating in intensity to that found in recovered cases of the disease.

Even this advance was subject to criticism, in that the injection of "mouse virus" is not unattended by risk, and further, the fact that the patient's blood actually contains the virus, even in a much modified form, introduces the possibility of its spread by mosquitoes and reappearance of its virulence. Sawyer, Kitchen, and Lloyd found that this difficulty could be overcome by mixing the "mouse virus" with immune serum obtained from human beings who had recovered from the disease, but the necessity of obtaining large quantities of immune serum from convalescent human beings prevented the general application of this method. Within the last few months, however, Pettit and Stefanopoulo have found that the serum of horses or baboons inoculated repeatedly with yellow fever virus acquires antiviral properties, and such serum may be used instead of the human immune serum. They found also that animal serum prepared in this way possessed greater immunity than human convalescent serum, and consequently smaller doses could be applied. This method requires further tests before it can be recommended for general use, but it promises to be a safe and practicable means of immunising the population in regions where yellow fever is present.

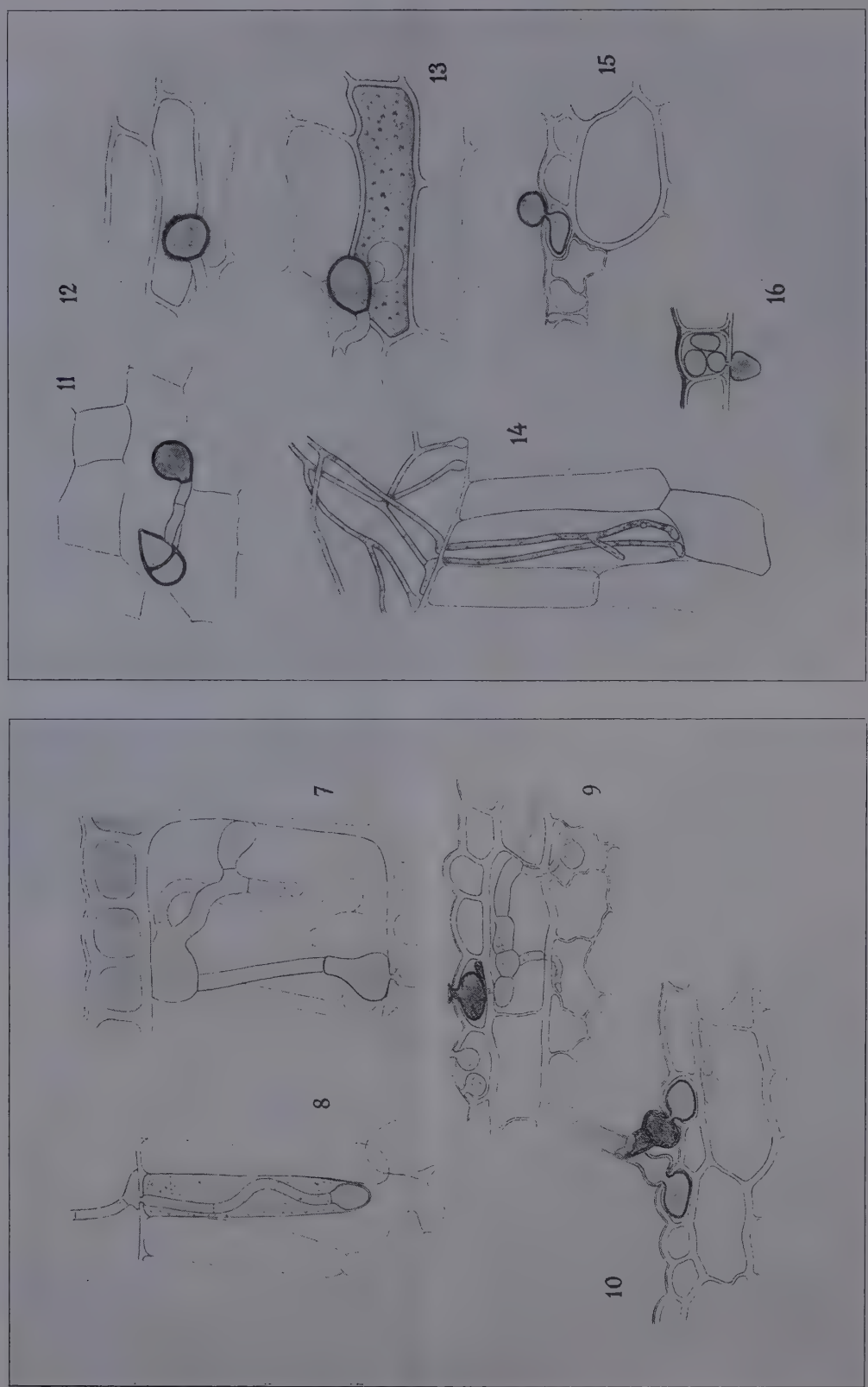
THE BANANA LEAF DISEASE IN SURINAM.





FIGS. 1–6. (*For captions, see text.*)

THE BANANA LEAF DISEASE IN SURINAM.



FIGS. 7–16. (*For captions, see text.*)

BANANA DISEASES IN TRINIDAD.

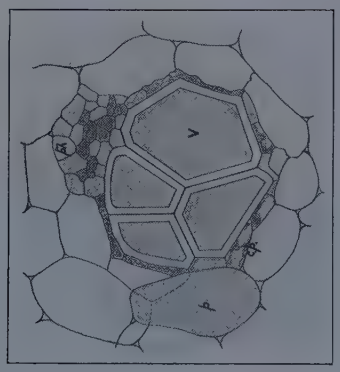


FIG. 1.

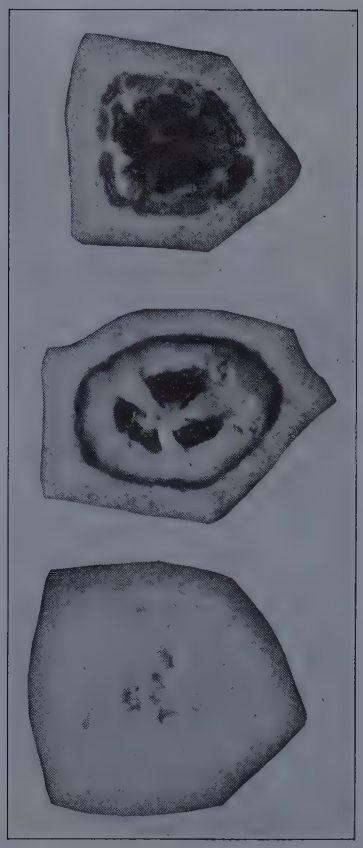


FIG. 2.

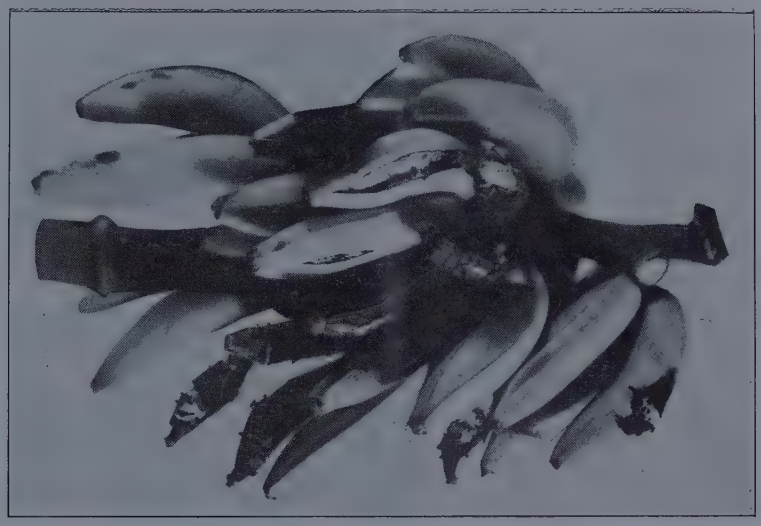


FIG. 3.

(For captions, see text.)

BANANA DISEASES IN TRINIDAD.

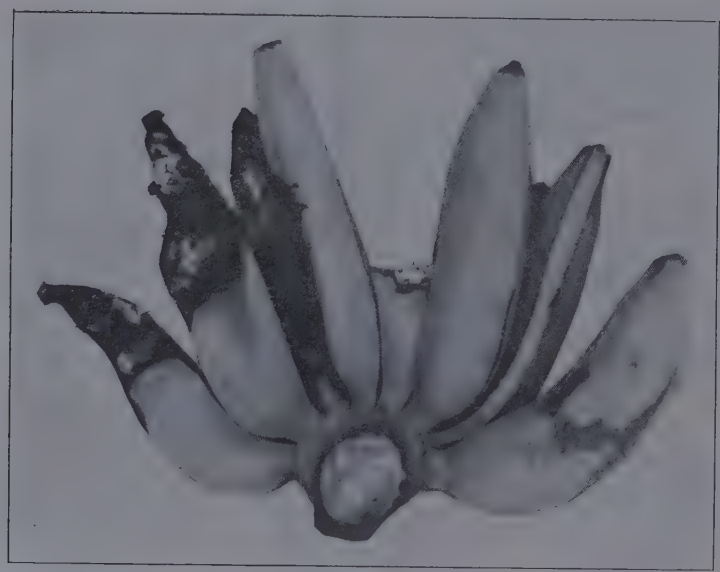


FIG. 4.

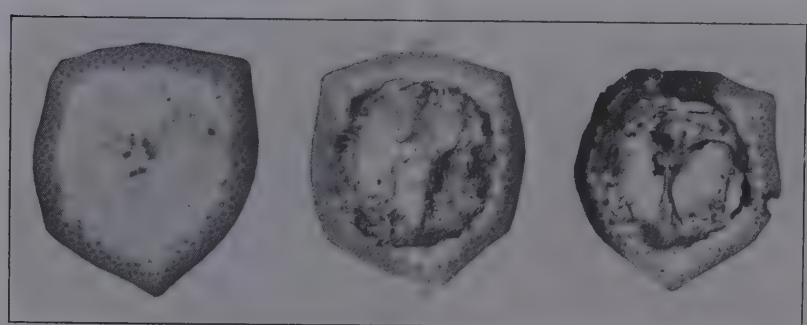


FIG. 5.

(For captions, see text.)

BANANA DISEASES IN TRINIDAD.

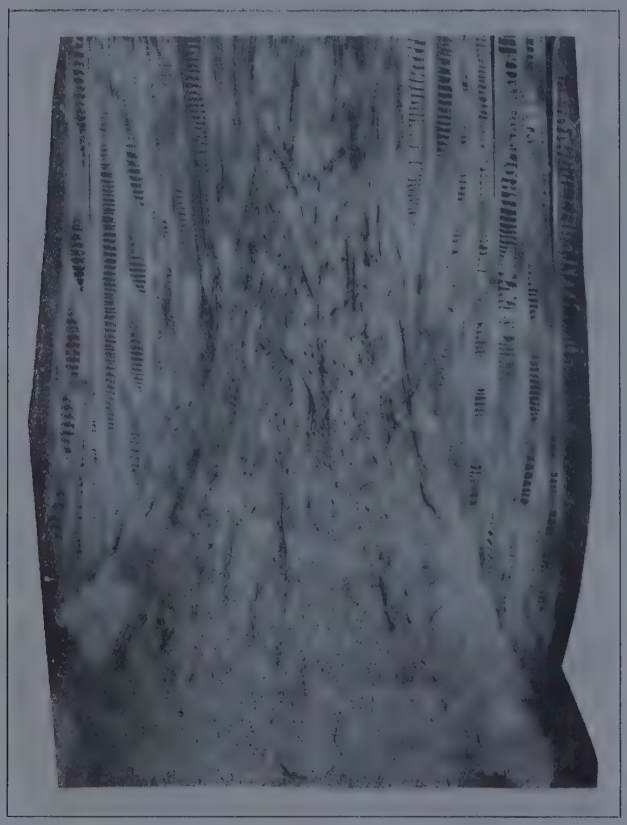


FIG. 6.

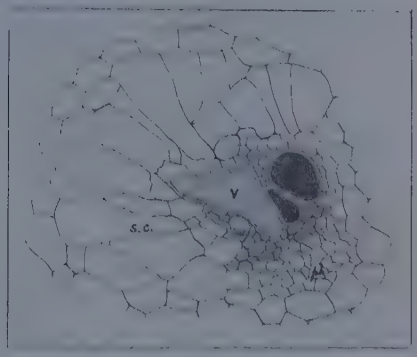


FIG. 9.

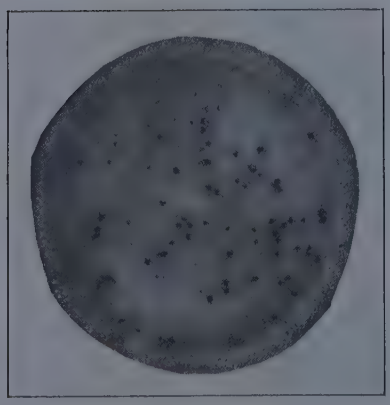


FIG. 8.

FIG. 7.

(For captions, see text.)

BANANA DISEASES IN TRINIDAD.

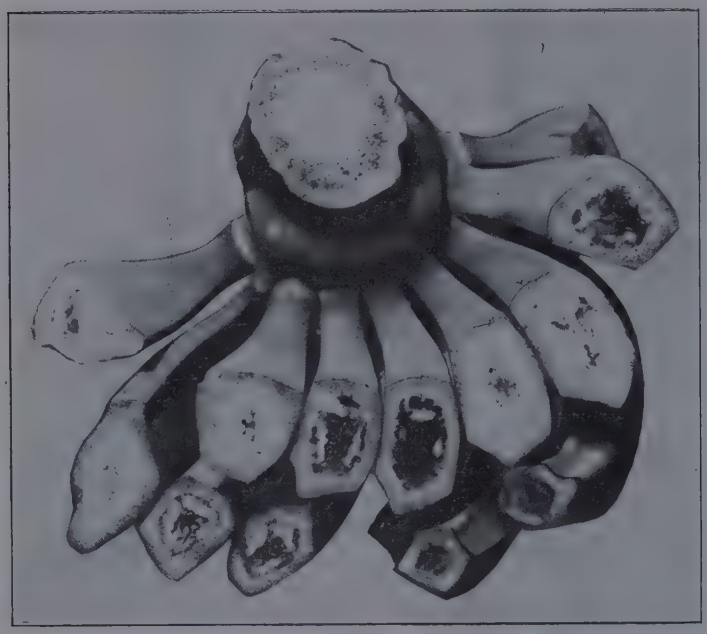


FIG. 10.

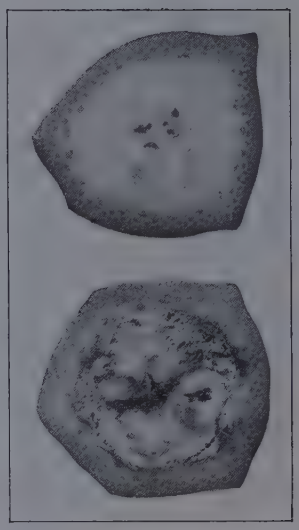


FIG. 11.

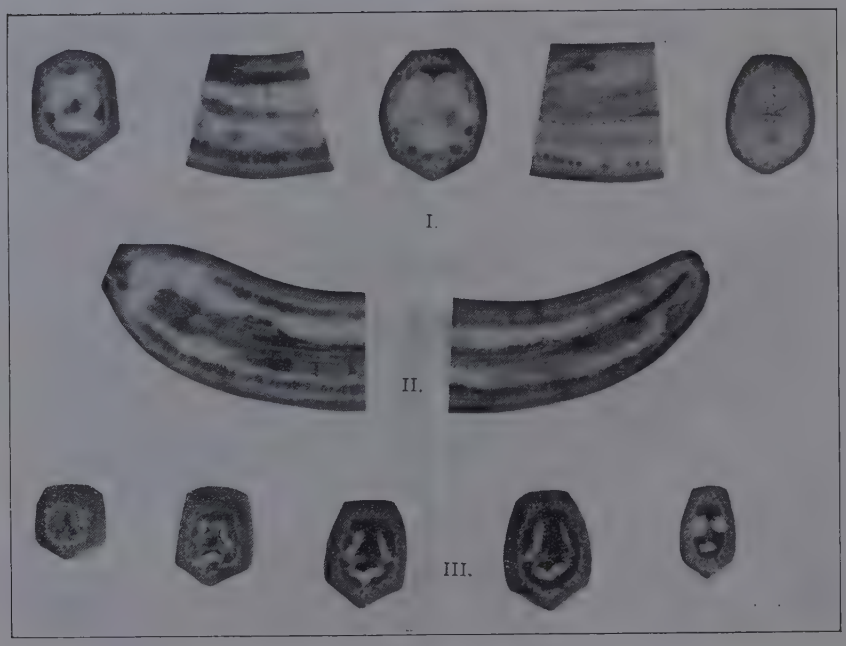


FIG. 12.

(*For captions, see text.*)

BANANA DISEASES IN TRINIDAD.

FIG. 13.

FIG. 14.

(*For captions, see text.*)

BANANA DISEASES IN TRINIDAD.

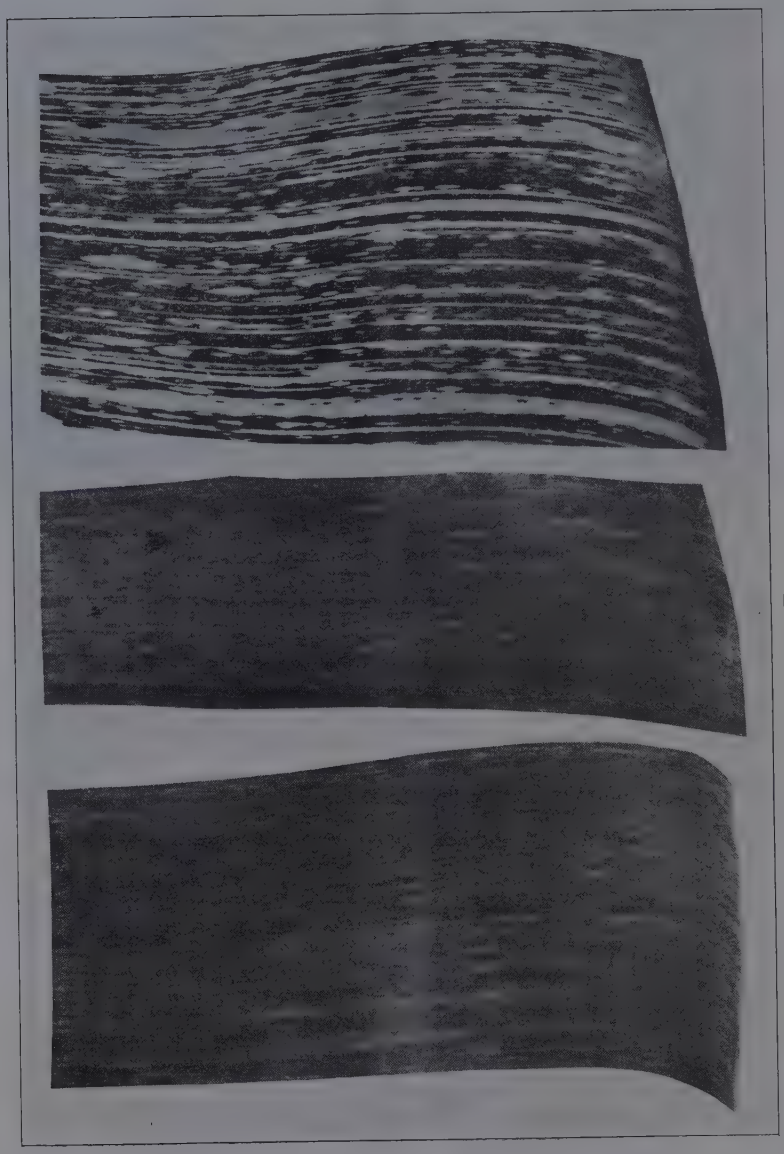


FIG. 15.

(For captions, see text.)

BANANA DISEASES.

VIII. Notes on Various Diseases Occurring in Trinidad.

By C. W. Wardlaw.

Bacterial Wilt Disease—Bacterial Disease of Cavendish Fruits—Panama Disease affecting Different Varieties—Heart Leaf Rot—Virus Disease—Cephalosporium crassum Petch on Pentalonia nigronervosa Coq.—Fruit Spots.

Bacterial Wilt Disease.—(Figs. 1-11.)

For many years Bacterial Wilt (*B. solanacearum* E. F. Sm.) or Moko Disease has been known in Trinidad affecting principally the Moko plantain and Cavendish variety. A recent localised outbreak of the disease in the Rio Claro District is of particular interest because of the high degree of susceptibility shown by the Gros Michel under the particular growth conditions there. Here it may be mentioned that although previous investigators (1, 11) had produced typical disease symptoms in this variety by inoculating with *B. solanacearum* E. F. Sm., cases of natural infection in the field had not been observed. The Gros Michel was accordingly thought to possess a high degree of resistance. In the light of current observations, Ashby's (2) comment on this point is interesting :

"Natural infection of Gros Michel has therefore not been observed hitherto either in Trinidad or British Guiana although the variety is susceptible to inoculation in the leaf-stalks, but further observations are necessary to decide if it is resistant in any notable degree under field conditions where other varieties have become diseased."

The area under consideration at Rio Claro is a peasant's cultivation, taken out of high woods some three years ago. The land-surface is uneven and the soil poor, compact and mottled. Its general unsuitability to the banana is clearly indicated by the smallish stature of the plants and the production of undersized bunches after only three years of cultivation. Bacterial wilt is present on three varieties, namely, the Gros Michel, the Moko plantain, and another plantain variety known as Bande.

Symptoms.

In all three varieties, the symptoms observed were not quite in accord with previous accounts. This, however, is not regarded by the writer as important diagnostically, as it is evidently referable to the onset of the disease at the height of the dry season in plants most of which were carrying a fairly well developed bunch.

Moko Plantain.—In diseased plants the lower or outermost leaves were withered and fallen ; the remaining leaves, though not vigorous and healthy, were not characterised by any marked discolouration. The observer's attention was chiefly attracted to affected plants by the appearance of the bunch, in which occasional fingers had become prematurely yellow.

On cutting open such yellow and green fruits, various stages may be observed in the disorganisation of the internal tissues : the vascular strands of the skin are yellow or brown, while the peripheral region of the pulp acquires a soapy yellowish-brown consistency ; this condition, gradually enveloping the entire pulp, is followed by desiccation and hollowing out of the tissue between the placentae ; finally the fruit flesh is reduced to a mass of crumbling dry, rotted tissue. These changes are accompanied by a premature yellowing of the skin, which may, at a later stage, become blackened by anthracnose blemishes (*Gloeosporium musarum* Cke. & Massee).

On cutting open the pseudo-stem and bulb, vascular strands discoloured yellow and brown as described by Rorer were readily apparent. A feature of the specimens under consideration was the localised distribution of the diseased strands : they were present only in the true stem (which ultimately terminates in the bunch) and in the inner leaf sheaths of the pseudo-stem. This explains the absence of conspicuous leaf symptoms. It may also be regarded as an indication that infection from bulb to pseudo-stem took place at a relatively late stage, *i.e.*, when the upward movement of solutes in the wood-vessels was largely confined to the central true stem and inner leaf sheaths.

Gros Michel.—The infected Gros Michel plants which came under observation were of smallish stature. They were entirely devoid of leaf symptoms indicative of wilt or other internal disease. As indicated above, this was clearly correlated with the internal distribution of the pathogen : on cutting the pseudo-stem of plants carrying a bunch, the discoloured vascular strands were again entirely confined to the central true stem and innermost leaf sheaths. The outermost leaf sheaths showed no yellow or brown vascular strands : the absence of wilt symptoms in the leaves is therefore not surprising.

In the early stages, the discoloured vasculars were pale yellow, later becoming dark brown or almost black. In infected daughter suckers the distribution of yellow diseased vasculars both in the bulb and pseudo-stem was normal, the outer leaf sheaths being most conspicuously affected. At the apex of such suckers a characteristic shrivelling and browning of the small arrow-shaped leaves had taken place (16).

In this phase of infection, mature Gros Michel plants can only be recognised by the appearance of the bunch. Here the symptoms are very

noticeable: individual fingers or groups of fingers become prematurely yellow and finally blackened and ruptured so that the dry-rotted condition of the pulp within becomes evident. By sectioning fruits at different stages the progress of the internal decline can be followed. Beginning at the infected yellow or brown vasculars of the skin, the disease first spreads to the peripheral region of the pulp and then inwards till finally the entire core is affected. The pulp is at first rendered dark or dull-coloured and soapy; it then undergoes desiccation and finally becomes dry and crumbling, accompanied by yellowing and rupturing of the skin.

Bande.—In this variety, with the exception that fruits were not so severely affected, disease symptoms were very similar to those described for the Gros Michel.

With the exception of the Moko plantain, which was usually considerably defoliated, reliance had to be placed on bunch symptoms in picking out infected plants. This, no doubt, is largely a particular seasonal manifestation of bacterial wilt disease; it is in agreement with some of Rorer's (11) original observations:

"If the disease is not severe, or a plant does not become infected until it has just formed a bunch of fruit it may remain perfectly healthy looking, but many of the young fruits, or "fingers", do not properly mature; they remain small and eventually become black and rotten. In such cases it is found that there are some discoloured bundles filled with bacteria in the leaves, stem, fruit-stalk, or fruits."

In general, the internal symptoms are not likely to be confused with those of Panama Disease, the reddish or crimson vasculars characteristic of the latter not being present in specimens of bacterial wilt. In some infected daughter suckers from bacterial wilt plants, however, the disposition and appearance of the affected vascular strands were very similar to those observed in certain stages of Panama Disease. In such cases a final diagnosis would depend on microscopic examination and the isolation of the pathogen. In this connection the possibility of the occurrence of joint bacterial and fungal infections should not be overlooked.

In each of the three varieties under consideration, exudation of a greyish-white to dark brown bacterial ooze from diseased vasculars was observed—a characteristic symptom never seen in Panama Disease. In some instances the bacterial ooze showed departures from the usual greyish-white appearance, yellow or other unusual colourations being interpreted as an indication of the presence of secondary organisms— a view fully confirmed in subsequent bacteriological studies.

Microscopic Examination.

In microscopic sections through vascular strands of (*a*) the bulb (*b*) the base of the pseudo-stem (*c*) the basal region of the true stem (*d*) the main-stalk of the bunch and (*e*) the skin of affected fruits, an abundance of bacteria, filling the vessel cavities and sometimes extending to the ground parenchyma, was invariably observed in each of the three varieties. This is in marked contrast to Panama Disease where the discoloured vessels normally contain a scanty mycelium only, the ground parenchyma remaining unaffected.

As the bacteria are present in great numbers, affected wood vessels are usually completely plugged. Of the vessels not occupied by bacteria some show a considerable development of tyloses, by which the lumena are also occluded. The typical wilt symptoms normally observed in the leaves and the irregular behaviour of affected bunches are consequently to be attributed to the influence of toxic secretions from infected vessels and to a curtailment of the transpiration stream.

Instances were also observed where the presence of bacteria in the vessels had stimulated the adjacent wood and conjunctive parenchyma to enlarge and divide, the pressure exercised by the expanding tissue resulting in a collapse or partial collapse of the infected vessel.

Isolation of *B. solanacearum* E. F. Sm.

In addition to the obvious exudation of bacterial slime in each of the three varieties, bacterial cultures were also obtained from all parts of the plant on Brown's synthetic medium (a potato-starch dextrose agar) by the poured plate method.

Small plugs of diseased tissue from different parts of the plant on being placed in media favourable to fungal growth failed to yield any mycelium whatsoever. As *F. cubense*, if present, would undoubtedly have yielded conspicuous fungal colonies in the course of a few days, it may safely be inferred that this organism was entirely absent in the specimens examined.

Many of the bacterial cultures obtained consisted of wet shining colonies on potato-dextrose agar and, on transference to steamed potato blocks, gave wet colonies rapidly turning brown and black. As already indicated, in some instances other secondary bacteria were also present, a yellow organism being occasionally obtained from the Moko plantain along with *B. solanacearum*. In advanced stages of infection the presence of secondary organisms is not unexpected.

Treatment.

It is not yet known to what extent outbreaks of bacterial wilt disease on the Gros Michel banana are localised. The presence of the disease on a highly susceptible variety—the Moko plantain—in close proximity may be regarded as an important accessory factor tending to establish the pathogen on the Gros Michel.

The immediate eradication of all diseased plants of the several varieties by the Gas Oil Treatment (13) or by burning is desirable. In the event of replanting of infected areas being considered worth while, large planting holes should be prepared and the soil thrown out and thoroughly exposed during the dry season. *B. solanacearum* is a short-lived organism and as it has no protected spore or encapsulated stage,

it is easily destroyed by aeration under dry conditions. Only large "bits" or "bulbs," assuring rapid growth of the new plant, should be used.

Bacterial Disease of Cavendish Fruits.—(Fig. 12.)

A disease of Dwarf Cavendish fruits, due to bacterial agency and hitherto undescribed, came to light during storage investigations in which the bunches were being cut up and crated as single fruits. Occasional fruits, particularly from the distal or lowermost hands, but occasionally from other parts of the bunch also, were observed to be abnormal in appearance. A search made on unreaped fruit in the field indicated that these diseased fingers were occasionally present in the lower hands of the bunches but less frequently in the upper hands.

Diseased fruits tend to be slightly irregular in shape, angular, small and incompletely developed, and sometimes prematurely ripened. The pulp, instead of being pure white and starchy, shows a yellowish-brown or rusty discolouration round the periphery and in the central core and more open tissues in the vicinity of the placentae. The colour in older specimens is deeper, finally becoming darkish crimson to brown. In severe infections the peripheral discolouration is more or less continuous: in less severe infections the progress of the pathogen through the tissues can be traced as a number of separate yellowish-brown streaks.

From an examination of a considerable number of specimens it has been ascertained that the disease invariably begins at the distal or stylar end of the fruit, and from there progresses through the more open tissues towards the finger-stalk. In sufficiently immature specimens (Fig. 12, I), the yellow streaks can be traced from the stylar end half-way or more along the fruit after which they disappear. In severe cases, the discolouration in the centre and periphery of the flesh (Fig. 12, II and III) may approach closely to the finger-stalk.

The bacterial pathogen gains access to the flesh by way of the stylar channel while the fruit is still very immature. It establishes itself in the loose, aerated, central and peripheral tissues of the young fruit, and in time progresses inwards. Microscopic examinations show that the organism multiplies chiefly in the intercellular spaces. Later these become brown and necrosed. The presence of the pathogen exercises a stimulating effect on the parenchymatous cells: they show a tendency to enlarge and divide and their normal starchy contents disappear; these changes may be accompanied by suberisation of the cell walls, or by necrosis and collapse of the cells. The presence of the invading organism makes for a diminished rate of growth; hence the small size, angular and irregular shape of affected fruits.

No difficulty was experienced in isolating the bacterium from early stages of the disease. On potato-dextrose agar numerous wet shining colonies were obtained, but the exact identity of the organism has not yet been established. On being inoculated as needle stabs into the distal ends of young fruits in the field, typical internal symptoms were produced, the bacterium making marked inroads along the central and peripheral regions in the course of ten days. Where the growth of the bunch was vigorous, particularly in the case of inoculated top or proximal hands, the fruits tended to outgrow the disease. In the more slowly-growing lower hands, however, well developed infections were established in the course of 25 days.

Older infections may become over-run by secondary fungi and bacteria. Diseased fruits are also liable to be infested by small scavenging insects. In a particular type of secondary infection, characteristic disease symptoms are obtained, occasional specimens developing a well defined tip-rot. This is accompanied by premature yellowing of the whole fruit. The organisms involved is *F. moniliforme* Sheldon var. *subglutinans* Wr. & Reink., the condition induced by its presence having already been described as Fusarium Tip-rot (15). In previous investigations this organism, though constantly associated with the tip-rot did not reproduce the symptoms on inoculation into sound fruits. On the other hand, the bacterial pathogen alone does not lead to decay at the distal end. The tip-rot ultimately produced in some specimens is therefore to be regarded as being in the nature of a compound infection.

The primary pathological condition described here is quite distinct from that induced in fruits as a result of Bacterial Wilt or Moko Disease. The symptoms are also dissimilar to those of Blood Disease of bananas—a bacterial disease described by Gaümann in the Dutch East Indies (4). A gumming disease, occurring in Australia, distinguished by a characteristic internal discolouration, has been attributed to winter injury and is apparently not due to the inroads of micro-organisms. Other internal fruit rots, such as "squirter" disease (*Nigrospora musae* McL. & Hoëtte) (5, 12) are referable to fungal agency.

Panama Disease affecting Different Varieties.

Specimens of a wilt disease affecting the "Rock Fig" variety in Grenada were submitted to the writer for identification: the internal symptoms were characteristic of Panama Disease and *F. cubense* was isolated from diseased vascular strands.

Considerable interest attaches to the degrees of susceptibility which different banana varieties exhibit towards Panama Disease. An unusual example was afforded by the Awak Legor, a Malayan variety introduced into Trinidad. As this had been successfully grown on a notoriously sick area for five years, it was thought to be quite immune or highly resistant to Panama Disease. During the sixth year, however, unmistakable external and internal wilt symptoms appeared, *F. cubense* being subsequently isolated from affected vascular strands.

In the College banana collection, *F. cubense* has been isolated from diseased vascular strands of varieties bearing the following labels: Gros Michel, Pisang Embun, Rio de Janeiro, Cinera, Mataboro (Green-Red), Silk, Cayenne, Bande, Awak Legor, and various Gros Michel seedlings (Gros Michel × *Musa acuminata*).

Heart-Leaf Rot.—(Figs. 13–14)

A disease, finally culminating in a downward rotting of the heart-leaf and core of the pseudo-stem, has been of consistent occurrence during the past rainy season on a Gros Michel seedling banana growing in the College variety plot.

In plants severely attacked prior to the shooting of the bunch, not only are disease symptoms evident at the distal ends of the older leaves, but the young unfolded central leaf is subject to a severe tip rot, accompanied by a pronounced blackening of tissue. This soon develops into a malodorous soft rot which works backwards along the unrolled heart-leaf into the pseudo-stem. From there, still confined chiefly to the heart-leaf, the infection passes downwards in the trunk finally rotting the apical tissues of the bulb itself. The leaves constituting the crown then tend to bend at the point of junction with the pseudo-stem and soon the whole trunk is readily pushed over.

Where the infection takes place at a later stage, a small bunch may be shot, but before this has filled out and matured, all the crown leaves are already broken down and a general soft rotting is present throughout the tissues at the top of the pseudo-stem.

Although severe rotting is not usually observed in the older leaves, many of them are subject to a localised tip-rot in which the tissues both of the midrib and lamina are affected. As a result the distal end of the leaf has a ragged, blackened appearance. On the surface of the diseased tissue, the spore beds of a species of *Fusarium*—identified by Doctors Reinking and Wollenweber as *F. moniliforme* Sheldon var. *subglutinans* Wr. & Reink.—are abundantly developed. From diseased tissues at all stages of infection this species and a small rod-shaped bacterium have been consistently isolated. Jointly these are apparently responsible for the soft rotting of tissues and for the offensive, butyric fermentation characteristic of the later stages of decay.

From the foregoing description of symptoms, it is evident that the disease increases in intensity from the earlier localised blackening of the tips of the older leaves to the final complete rotting of the central heart-leaf. Anatomical observations suggest that, among other factors, the influence of toxic secretions derived from the pathogenic organisms are probably important in producing this effect. Sections through the midrib, taken below or in proximity to diseased tissue of the lamina, show that almost invariably changes have taken place in the vascular strands: not only are the tissues discoloured and necrosed, but various anatomical changes related to the presence of toxic or stimulating substances may also be observed; these include the obliteration of vessel cavities by the expansion of the conjunctive parenchyma, and the blocking of vessel cavities by tyloses.

Various heart-leaf rots of the banana and the Manila hemp plant (*Musa textilis* Née) have already been described. As a rule fungi, including *F. moniliforme* var. *subglutinans* (7, 10,) and bacteria are found in association, but fundamentally other factors predisposing plants to attack are present.

In inoculation experiments, Ocfemia and Mendiola (7) applied *F. moniliforme* var. *subglutinans* to wounded and unwounded unrolled heart-leaves with positive results, provided the plants were maintained under very moist conditions. The fungus is apparently weakly parasitic, being able to attack the young and tender tissues of plants debilitated by Bunchy top, root disease or borer infestation (10).

Referring particularly to the present case, general adverse growth conditions and the continuous lodging of water in the crown or funnel of the plant during continuous wet weather may be regarded as partly responsible. The fact that other varieties in close proximity have not suffered, however, suggests that genetic factors may, in this particular instance, be important. This may take the form of a constitutional weakness. The disease may also be referable to injuries sustained by the young emerging leaf tips as a result of over-compression at the crown of the plant—an observation suggested by a characteristic wrinkled, compressed appearance which persists even in the adult leaf.

Virus Disease.—(Fig. 15.)

For a number of years an abnormal leaf condition considered to be in the nature of a virus disease has been observed by the writer in Trinidad, the Dwarf Cavendish and Giant Fig varieties being affected. So far there is no evidence that this disease is serious, either in regard to its destructive effect on the individual plant, or in the matter of rapid spread. Occasional specimens may be observed in different parts of the Island. The disease is, however, of considerable scientific interest in that it bears a close resemblance to a new and destructive virus disease of bananas (not Bunchy top) recently described by Magee (6) in Australia. Furthermore, the Trinidad disease is thought to be identical with one observed in the state of São Paulo, Brazil (16); in the latter instance, though apparently not actively destructive to plants, the disease was undoubtedly spreading on both the Dwarf Cavendish and Giant Fig varieties. Ogilvie (8) in Bermuda, has made a brief reference to a leaf mottling of Cavendish bananas closely resembling mosaic. The disease under consideration as observed by the writer in Brazil and in Trinidad is quite distinct from the Australian Bunchy top.

Symptoms.

Affected leaves are characterised by a distinct mottling. The latter consists of light chlorotic linear areas extending as irregular, broken, sometimes anastomosing, lines or stripes from the mid-rib to the leaf margin. The chlorotic areas may be quite whitish in young leaves or slightly pigmented to a pale yellow colour in older ones. On the older foliage, symptoms tend to be masked, but on proceeding to the younger leaves an intensification of the mottling is generally observed. In some leaves the mosaic symptoms may be present over the entire leaf surface, in others only localised bands or isolated spots may be present. With age the chlorotic stripes acquire yellowish, brownish-red and finally bluish-black hues, so that affected leaves stand out conspicuously.

There is abundant evidence that the disease is systemically distributed throughout the entire stool, as many as six daughter suckers, of different ages, showing typical leaf discolouration.

No evidence has so far been obtained that the presence of the virus seriously militates against the health or productiveness of the plant. Plants with well marked leaf symptoms bear normal bunches and stools have been observed where bunches, with typical mosaic mottling on the fruit-skin, have been produced year after year.* Again, cases culminating in heart-rot, *i.e.*, rotting of the young central leaf and core of the pseudo-stem, as in the Australian disease, have not come to the writer's notice either in Brazil or in Trinidad.

The characteristic leaf markings, the intensification of symptoms in the younger leaves, and the transmission of the disease systemically through the stool are all indicative of infectious chlorosis, while the constant occurrence in plantations of *Pentalonia nigronervosa*, the banana aphis, suggests the agent by which the virus might be transmitted.

Leaf symptoms tend to come and go according to seasonal and cultural conditions. In Brazil, leaf mottling is much more noticeable during the cold dry season when growth is virtually at a standstill. When rapid growth is resumed with the advent of hot weather, mottling may disappear or become more or less completely masked. Mosaic symptoms also disappear on plants which have undergone rapid growth as a result of manurial treatment.

Transmission Experiments.

Young suckers from heavily infected plants were potted and kept in a glass house. Aphids from bananas were placed in the crown of these plants, and, under the protected conditions provided, bred rapidly so that the young petioles were covered with aphids at all stages of development. This was particularly marked in plants protected in muslin cages. At the same time comparable suckers from healthy plants were grown under the same conditions. Transference of aphids was effected by cutting off heavily infested young leaves and petioles and placing these in the funnel of the partly unrolled heart-leaf of a healthy plant. Although the transferred aphids bred rapidly and despite the fact that fresh batches were established from time to time, no mosaic symptoms appeared on the healthy plants in the course of five months. Various devices such as providing drought conditions and pruning off the leaves or even the whole crown were tried to see if possible latent virus infections could be brought out, but these also were attended with negative results.

Meanwhile, in another series of experiments, exceedingly small "eyes" or buds from diseased plants had been carefully rooted. Without exception the first and later leaves produced showed the characteristic mosaic symptoms.

The Australian Disease.

The Australian infectious chlorosis is also characterised by a yellow mottling of the leaves (6). In addition, affected leaves acquire a markedly sinuous margin, they are brittle and tend to occupy a rather erect position. Some of the virus-infected plants finally die as a result of heart-rot, *i.e.*, a downward rotting of the unrolled inner leaf. While the earlier mosaic symptoms are evidently closely similar to those described above, the Australian disease undoubtedly exercises a much more destructive effect than that observed in the Caribbean region and South America. The evidence available is still insufficient to decide whether the two diseases are alike or distinct.

Cephalosporium crassum Petch on *Pentalonia nigronervosa* Coq.

During investigations of the virus disease on the Cavendish variety, the banana aphis *Pentalonia nigronervosa* Coq. was under close observation both in the field and in the greenhouse. During the wet season the aphid was frequently observed to be parasitised by a fungus. The latter consists of soft white tufts of hyphae growing out from the leg joints and body. This organism is in complete agreement with that observed on *P. nigronervosa* in the Philippine Islands and named *Cephalosporium crassum* n.sp. by Petch (9).

Under moist conditions, there is little doubt that this fungus exercises a considerable measure of control on the spread of the banana aphis, entire colonies being killed out.

Fruit Spots.

Towards the end of the rainy season, unreaped bunches of Gros Michel, approaching three-quarters full, and of a plantain variety, Bande, were observed to develop small, brown, sunken spots, one-eighth of an inch in diameter. Although spotted bunches were of occasional occurrence only, some of the individual fruits were severely affected. *Glomerella cingulata* (Stonem.) Sp. & Von Schrenk, with the

* Information by courtesy of a Brazilian correspondent.

accompanying conidial stage, *Gloeosporium musarum* Cke. & Massee, was consistently isolated from both varieties. Hitherto *G. musarum* had only been observed in the Caribbean region as a storage pathogen (14): in India, Ceylon and the Philippine Islands, on the other hand, it is known as an active parasite on green fruit in the field. The oriental and occidental strains of the fungus are morphologically indistinguishable (3). The present observations indicate that Trinidad strains of the fungus may occasionally, under certain climatic conditions, also behave as parasites on unreaped green fruit.

Purplish-brown, sunken blemishes, with a central raised spot, occurring during the dry season on the underside of the lowest hands of unreaped Dwarf Cavendish bunches, must apparently on the mycological evidence be referred to the activity of sucking insects. Round the central feeding puncture a small blob of mucilage is present on many of the spots, and although little tufts of *Cladosporium* sp. were frequently observed there, no organism was isolated when the innermost tissues of a considerable number of spots were carefully plated out on culture media. Similar spots, observed on the Dwarf banana in Australia, and figured by Veitch and Simmonds (17) have been attributed to Coreid fruit-sucking bugs.

Literature.

1. Ashby, S. F.—A Wilt Disease of Bananas. *Tropical Agriculture*, III, 1926.
2. Ashby, S. F.—The Bacterial Wilt of Bananas and Plantains. *Agric. Journ. Brit. Guiana*, 1, 4, 1928.
3. Ashby, S. F.—Gloeosporium Strains. *Tropical Agriculture*, VIII, 12, 1931.
4. Gaümann, E.—Investigation into the Blood Disease of Bananas on Celebes Island. *Meded. Inst. voor Plantenziekten, Bull.* 50, 1921. (English Summary).
5. McLennan, E. I. and Hoëtte, S.—Nigrospora musae n. sp. and its connexion with "Squirter" Disease in Bananas. *Counc. Sci. Ind. Res.*, Australia, *Bull.* 75, 1933.
6. Magee, C. J.—A New Virus Disease of Bananas. *Agric. Gaz. N.S. Wales*, XLI, 12, 1930.
7. Ocfemia, G. O. and Mendiola, V. B.—The Fusarium Associated with some Field Cases of Heart Rot of Abacá. *Philippine Agric.*, XXI, 1932-33.
8. Ogilvie, L.—*Rept. Dept. Agric.*, Bermuda, 1927.
9. Petch, T.—Notes on Entomogenous Fungi. *Trans. Brit. Myc. Soc.*, 16, p. 72, 1931.
10. Ramos, M. M.—Mechanical Injuries to Roots and Corms of Abacá in Relation to Heart Rot Disease. *Philippine Agric.*, XXII, 1933.
11. Rorer, J. B.—A Bacterial Disease of Bananas and Plantains. *Phytopath*, 1, 1911.
12. Simmonds, J. H.—Squirter Disease of Bananas. *Queensland Agric. Journ.*, August, 1933, *Pamphlet* No. 11, *Dept. Agric. & Stock*, Queensland.
13. Smith, F. E. V.—Panama Disease. The Use of Chemicals for Killing Bananas in the Treatment of Panama Disease. *Tropical Agriculture*, IX, 3, 1932.
14. Wardlaw, C. W.—Notes on the Parasitism of *Gloeosporium musarum* Cke. and Massee. *Tropical Agriculture*, VIII, 12, 1933.
15. Wardlaw, C. W.—Notes on a Fusarium Tip-rot of immature Cavendish Fruits. *Tropical Agriculture*, X, 1933.
16. Wardlaw, C. W. and McGuire, L. P.—Cultivation and Diseases of the Banana in Brazil. *Tropical Agriculture*, X, 1933.
17. Veitch, R. and Simmonds, J. H.—Pests and Diseases of Queensland Fruits and Vegetables. *Queensland Dept. of Agric & Stock*, 1929.

Index of Illustrations.

(Figs. 2, 3, 4, 5, 6, 7, 8, 10, 11, 13, 14: Photographs by F. W. Urich; Figs. 12 and 15 by the Tucker Picture Coy.)

Fig. 1.—Moko Plantain: section through true stem in basal region of trunk (pseudo-stem), showing the wood-vessels (v) filled with bacteria; on the left, bacteria passing out from the vessels have infected cells of the conjunctive parenchyma (c.p.) and a large parenchymatous cell (p.) of the bundle sheath; (ph.), phloem. (× 130.)

Fig. 2.—Moko Plantain: sections through fruits; left, normal fruit; middle and right, fruits affected by bacterial disease. (Natural size.)

Fig. 3.—Gros Michel: bunch of fruit showing diseased condition of individual fruits—the result of infection by the bacterial wilt organism (*B. solanacearum*). Note the blackened, shrivelled, ruptured and prematurely yellowed condition of some of the fruits.

Fig. 4.—Gros Michel: blackened, shrivelled and fissured condition of fruits from plants affected by Moko disease.

Fig. 5.—Gros Michel: sections through fruits; left, normal fruit; middle and right, fruits from a plant infected by *B. solanacearum*.

Fig. 6.—Gros Michel: longitudinal section through head of bulb, showing the dark infected vascular strands passing upwards into the true stem. Only a few diseased vasculars pass out to the leaf bases (compare Fig. 7).

Fig. 7.—Gros Michel: transverse section near base of pseudo-stem. The bacterial infection is localised chiefly in the central true stem and inner leaf-sheaths; the vascular strands of the outer leaf-sheaths are not affected.

Fig. 8.—Gros Michel: transverse section of main-stalk of bunch showing vascular strands affected by bacterial wilt disease.

Fig. 9.—Gros Michel: transverse section through infected vascular strand near base of pseudo-stem: (v) vessels filled with bacteria; on the right two vessels are plugged with dark brown wound gum. As a result of bacterial invasion the sheath cells (s.c.) have been stimulated; they have enlarged and brought about a partial collapse of the infected vessel: the conjunctive parenchyma is dark and necrosed; ph., phloem. (× 60.)

Fig. 10.—Fig Bande: fruit from a plant affected with Moko disease: the diseased condition of the vasculars in the main-stalk and in the individual fruits is readily apparent.

Fig. 11.—Fig Bande with Moko disease. Healthy and diseased fruits in section.

Fig. 12.—A Bacterial disease of Cavendish fruits.

Fig. 13.—Gros Michel seedling : leaf and crown rot of bananas (*Fusarium moniliforme* var. *subglutinans*) ; left, blackened tip of young central or heart leaf ; middle, blackened tip of older leaf, accompanied by destruction of the lamina ; right, final stage showing all the leaves wilted and the undersized bunch.

Fig. 14.—Gros Michel seedling : section through base of pseudo-stem, showing the result of downward rotting of the heart-leaf. The young bud at soil level is finally rotted.

Fig. 15.— *Virus disease* : three stages in the development of a characteristic leaf mottling in the Cavendish variety.

REVIEWS.

THE TOXICOLOGY OF PLANTS IN SOUTH AFRICA TOGETHER WITH A CONSIDERATION OF POISONOUS FOODSTUFFS AND FUNGI.

BY D. G. STEYN, B.SC., DR. MED. VET. (VIENNA), D.V.SC., *Central News Agency Limited*, South Africa, 1934, pp. 632. £2 7*s*. 6*d*. Obtainable from Gordon and Gotch, London.

The author of this book is Head of the Department of Pharmacology and Toxicology, Onderstepoort Laboratories, Transvaal, and writes authoritatively. The first 73 pages, "General Toxicology of Plants" touch upon a score of distinct aspects of poisoning by toxic plants, and necessarily dismiss many of them very briefly, though with reference to literature which prove careful preparation of this general review of the subject. Sections follow on Poisonous Foodstuffs, Photosensitisation, Food Rashes and Fungi in Relation to Health in Man and Animals. Systematic treatment of the poisonous plants of South Africa occupies pages 192-559, and is veterinary rather than botanical. The plants are not actually described, but their Latin, English, Afrikaans, and in some cases native names are given, and the majority are illustrated by excellent photographs. The active principle, toxicity, symptoms, post mortem appearances and treatment of the poisoning are the main points dealt with in each case. The thoroughness of the work is well indicated by the bibliography, of some 700 or 800 references, and by the Index, which itself occupies 23 pages of close type. The technical production of the volume is worthy of the immense amount of work which has evidently gone into its compilation.

E. E. C.

* * *

TWENTY WEST AFRICAN TIMBER TREES.

By L. Chalk, J. Burtt Davy, H. E. Desch, A. C. Hoyle, *Clarendon Press*, Oxford, 1933, pp. 108. Price 7*s*. 6*d*.

This publication forms number II of the series "Forest Trees and Timbers of the British Empire". The selection of species for description has been based on the present or potential commercial importance of their timbers. The trees are accorded a general and a botanical description, together with an account of the habitat and distribution, and the wood is minutely described as regards general properties, microscopic and macroscopic features. The publication is excellently illustrated, each species having one or more photographs of the tree in its natural habit, and two photomicrographs of the wood, in tangential and transverse section, respectively. In addition, the taxonomic description of each species is aided by clear drawings of the floral parts, fruit, and foliage habit.

E. E. P.

* * *

BLATTER, E. S. J., PH.D.—Flora Arabica. The Botanical Exploration of Arabia. *Rec. Bot. Survey Ind.*, Vol. VIII, No. 5, Manager of Publications, Delhi, 1933, Rs. 0 As 12, or 1s. 3d. pp. 451 to 500.

Although this paper is concerned only with botanical references in the literature of Arabian travel and exploration, it is of interest to agriculturists because it is this literature which contains almost all the published references to Arabian agriculture. The list of Arabs, who have dealt with agriculture in Arabia, or in whose works references to it can be found, is not complete ; but very few works on this subject in European languages are missing. In all, 435 original books and papers are listed beginning with the Bible and ending with LAURENT-TÄCKHOLM, VIVI. *Some New Plants from Sinai and Egypt*, 1932.

The total number of travellers mentioned is 192, beginning with Herodotus and ending with Miss Laurent-Täckholm. Of these, 30 seem to have visited only Sinai, and 36 only Aden or Perim. The better known of the travellers are Niebuhr (1761), Burckhardt (1809), Wallin (1845), Burton (1853), Palgrave (1862), Schweinfurth (1868), Doughty (1875), Hurgronje (1887), Philby (1917). The more noted botanists who have visited Arabia are Forskall (1761), Seetzen (1820), Boissier (1846), Brandis (1855), Schweinfurth (1868), Balfour (1880), Post (1884), Deflers (1885).

Only one traveller has devoted his attention primarily to a study of Arab agriculture, though Niebuhr (1761) did not neglect that craft on his vast and profound survey of Arabia. Niebuhr illustrates many agricultural implements and, amongst a variety of other agricultural information, describes methods of tillage in various parts of the country, and also gives lists of date varieties. Similarly, Doughty (1875), has a great deal to say in his two massive volumes about agriculture and stock raising in Arabia. Ibn al'Awam (twelfth century), di Barthema (1535),

Sadlier (1819), Palgrave (1862), Bury (1911), and Cheesman (1926) and others contribute notes on the agriculture of the districts through which they passed.

The solitary agriculturally-minded traveller was de la Roque (1708), who describes at length the coffee plant and its cultivation in the Yaman. For this plant, see also Fuchs (1885) and Watt (1907).

The date-palm has received short notices from most travellers, particularly Ibn Batuta (1330), Chedufau (1843), and others already mentioned. Ritter (1846) and Fischer (1881), though themselves not travellers in Arabia have written of the palm in that country.

Incense is mentioned by Agartharcides about B.C. 104, Carter (1848), and Bent (1895), and spice both by Herodotus (about B.C. 440) and Agartharcides.

A text-book in a European language on Arab agriculture has yet to be written; but in Father Blatter's excellent and particularly interesting paper are collected a list of almost all the raw materials at present available for such a work.

One mistake is noted: THOMAS, B. S. *Alarms and Excursions in Arabia is not* "An account of his great journey against the Great Desert of South Arabia".

H. V. W. D.

* * *

RECENT ADVANCES IN THE STUDY OF PLANT VIRUSES.

By Kenneth M. Smith, D.Sc., Ph.D. *J. and A. Churchill*, London, 1933; pp. 423+xii.; 15s.

Research into the nature and activities of plant viruses has made rapid progress during the last 20 years and a vast amount of information on the subject has been accumulated. It is difficult for anyone not actually engaged in the study of these organisms to keep abreast of the current literature on the subject and the need for a book giving an adequate picture of the situation at the present day has been widely felt. Dr. Kenneth Smith's book most admirably fulfils this want and should be of great value and interest to all who are concerned with this puzzling group of plant diseases.

In this book plant viruses are discussed from many aspects, and the various theories which have been advanced to explain different phenomena are dealt with from all points of view, especially in the light of the author's very considerable experience of the potato virus disease complex. The manner in which the author has succeeded in bringing into line the remarkably diverse results of workers on plant and animal viruses considerably enhances the value of the work.

The problem of the classification and description of plant virus diseases and the drawbacks inherent in any existing system are fully dealt with, and the difficulty of classifying something invisible by its reactions alone is stressed. Several chapters are devoted to the question of the relation between insects and viruses and to the various methods by which the diseases are transmitted. The author has had very considerable experience of this aspect of the problem and these chapters are full of interest. Finally a brief classification and description of all known plant virus diseases is given which adds considerably to the value of the book for purposes of reference.

R. E. D. B.

* * *

WORLD SUGAR PRODUCTION AND CONSUMPTION.

By C. J. Robertson, B.Sc., M.A., Ph.D. *John Rale, Sons & Danielsson, Ltd.*, London: 1934, pp. 142, 5s. net.

In this volume the economics of world sugar production and consumption are surveyed. In the early chapters an outline of the world trade in sugar is given and the general conditions of cane sugar and beet sugar production are dealt with. This is followed by descriptions of the principal producing countries or groups of countries, separate chapters being allotted to Cuba, Java, India, the British Empire producers excluding India, and the United States producers including the Philippines, other cane sugar producing countries and Europe and the Soviet Union. In each description the historical, climatic, soil, labour, factory, political and statistical aspects are dealt with. A special chapter is devoted to the refining industry, the book closing with a discussion of the main factors affecting the demand for sugar and of the prospects of world production and consumption.

It is shown that while the countries with higher rates of consumption per head are roughly those with a relatively highly urbanized population, high standards of living and lower rates of taxation of the commodity, the countries with lower rates of consumption are predominantly agrarian with generally low standards of living and high rates of taxation. Thus growth in consumption is likely to be more promising in those countries where the standard of living is capable of being raised. Attention is drawn to the need for improving the statistical basis of consumption studies as it is pointed out that there is nowhere anything like adequate statistical information of this type.

The book is packed with useful information, and the author is to be congratulated on the manner in which he has presented his facts. The book should not only appeal to those interested in commercial education and to the economist, but also to the producer.

G. G.

WE have received catalogue No. 24 which is one of the latest lists issued by Cooper, Pegler & Co., Ltd. of their Vermorel "Eclair" Spraying, Limewashing, Disinfecting and Creosoting Machines. Of special interest are the Knapsack and Hand Power sprayers which can work at pressures of up to 175 lb. and 300 lb. per square inch. Copies of the Catologue may be obtained from 24D-26A, Christopher Street, Finsbury Square, London, E.C.2.

IMPRESSIONS OF THE CACAO INDUSTRY OF GRENADA.

By A. W. Paterson, N.D.A.

To one familiar with cacao in West Africa, the cacao industry in Grenada presents a number of distinctive and outstanding features. On arrival, the visitor is struck with the mountainous and rugged nature of the island, a factor which must be borne in mind when it is seen that cacao is grown without shade. Although there is no special planted heavy overhead shade as in Trinidad, it is common to see large trees such as nutmegs and breadfruit interplanted with the cacao, particularly at higher elevations where the former are ousting cacao and on peasants' holdings. Whilst there is no regular shade, one of the outstanding features is the care taken to protect the cacao by means of hedges and windbreaks. The best hedges seen were of *Aralia guilfoylei* whilst lines of *Calophyllum calaba* made an excellent windbreak. The writer was greatly impressed by the skilful siting of many of these windbreaks on the better estates.

The close planting (400-500 per acre), the pruning to maintain a complete overhead canopy with no suckers allowed to develop, and the practically pure stand of cacao were points of resemblance to the Gold Coast, but there the comparison ended. Draining is carefully done, and before the present world wide economic depression, this cacao was probably the most intensively cultivated in the World. Large numbers of stock were kept for the production of pen manure, and heavy dressings of this were forked in about every five years on the best estates, liming was carried out and the use of chemical manures quite common. The amount of cultivation carried out has been reduced except on one large estate where it was stated that with careful management it was still possible to carry out most of these operations and show a profit.

The general variety is "Forastero" but a much lower type than general in Trinidad or even the Gold Coast, the beans usually being much smaller and requiring longer fermentation to produce the desired break. The care exercised in the fermentation of the beans on the large estates in order to produce as good a quality product as possible would be a revelation to the West African producer. The beans are turned every day, and in one instance the writer noticed that not only were the beans changed from one box to another, but also that they were shovelled out on the second day on to a concrete floor, and all pieces of placenta, diseased and unripe beans removed, before being shovelled into the second box. The extra labour involved in the double handling was no doubt compensated for by the thorough aeration and mixing of the beans ensuring a complete and equal fermentation. Grenada cacao is all danced or polished by treading, and old open sugar pans are used for this purpose instead of the flat drying platform as in Trinidad. It was stated that the "coppers," as they are called in Grenada, enable the polishing to be done more rapidly and better than by the other method.

In Grenada, all dealers in produce must be licensed (fee £5 per annum). Two types of licences are issued for cacao, one for dried and prepared cacao, and one for wet cacao. The latter is only issued when the applicant has satisfied the officer in charge of the Agricultural Department that he has adequate means for fermenting and drying such wet cacao. Many estates have this type of licence, and purchase the raw cacao from neighbouring peasant proprietors and produce a better quality product than could be done by the peasants themselves.

The most recent development, however, has been the introduction of an Ordinance to prohibit the export of unfermented cacao. The difficulty of describing unfermented cacao has been overcome by defining it as "cocoa of a standard of less than seven days fermentation, and containing more than five per centum of unfermented beans, and includes washed cocoa." The penalty is severe, a fine up to £100 with the option of three months imprisonment with or without hard labour, together with forfeiture of the produce. At the discretion of the Officer in Charge, Agricultural Department, an exporter may be given an opportunity of reconditioning his produce if it fails to reach the required standard. Any aggrieved party has the right of appeal, on deposit of a sum to cover expenses, to a Board of Appeal whose decision is final.

At the commencement, 1st October, 1933, comparatively few of the merchants welcomed the scheme, but now they are co-operating in a way that augers well for the future. The Produce Inspector reports a considerable improvement in the quality of estate cacao, and whilst peasants' produce is giving more difficulty, it is certainly of a much higher standard than formerly. The difficulty is that some irresponsible dealers are mixing unfermented cacao with well prepared produce, but no doubt enforcement of the law will soon remedy this, so far on proceedings having been taken.

Grenada is to be congratulated on the stand that it is taking at this time, in connection with this matter. The production of an even grade of well fermented cacao should ensure a safe market for Grenada produce even in these times of over-production.

FOR SALE.

Selected Malay Dwarf Coconuts.

Green or Yellow.

Apply :—Manager,

Londonderry, Choiseul *St. Lucia, B.W.I.*

CROP PRODUCTS MANUFACTURE IN 1933.

(*Abstracted from "The Industrial Chemist"*, January, 1934.)

Oils, Fats and Soaps. By *Rex Furness.*

No fundamental or striking development has occurred during the year in the technology of oils, fats and soaps, although considerable improvements are reported in matters of detail—soap-making plant generally, oil-extraction apparatus, and refining, deodorising and bleaching methods. Manufacturers are striving to present their products in a form which will assure to the consumer a perfectly satisfactory article if used at any reasonable period of time after its manufacture. Numerous materials have been suggested as additions to fats and oils for retarding or preventing oxidation and rancidity, and a recent addition to the so-called "anti-oxidants" used for delaying the development of rancidity in fats is gum guaiac. Many of the well-known anti-oxidants are water-soluble, and though satisfactory for use with fats and oils themselves, they do not preserve certain products in the making of which fats and water enter, such as biscuits and pastries. Thus it is likely that the water-insoluble, colourless, odourless, tasteless, and non-toxic substance, gum guaiac, used even at so low concentrations as 0.01 per cent., represents an advance in the presentation of food products containing fat.

Coloured Wrappers.—A change will probably take place also in the colour of the paper wrappers used with many types of preserved foods, not as a form of advertisement, but because of recent researches on the effect of light of different wavelengths on the finished product. It has been known for some time that fats and food products deteriorate when exposed to light in the presence of oxygen, while there is always sufficient oxygen present even in an "airtight" wrapper to bring about definite rancidity in time, particularly in strong light. But it was discovered recently that the effect of light upon fats differs markedly as the wavelength of light is altered. This has naturally suggested the use of wrappings of a definite colour capable of absorbing that particular band of light which is most favourable to fat oxidation. Ultra violet light and certain portions of the visible spectrum greatly accelerate the oxidation of fats: the yellow orange band is very active, while the green and red bands, of relatively high wavelengths, have the least effect. As an example of the practical application of the use of coloured wrappers, it was found that potato crisps in a green container were sweet and edible after one month's storage, whilst in other containers they became rancid after two weeks. Green cellulose wrappings also aided the preservation of the colour and clarity of bottled fruits.

Palm Oil.—Recent developments in the production of palm oil have followed the lines of obtaining high yields of first quality oil from cultivated estates, as opposed to the generally inferior native oils. By attention to the botanical species of the tree, application of fertilizers, and improvements in the methods of extraction, storage and transport, a larger proportion of better palm oil is now available than in earlier years. It has been known for some time that there is a difference in the composition of palm oils from different regions, but it is only recently that a full study of the matter has been made by Hilditch and Dean. They suggest that oils from the cultivated palms owe their composition entirely to the variety from which they originated, and are not altered in character by differences in external factors.

Vegetable Oil Extraction by Bacterial Methods.—The Beckman process, which was fully described in 1930* has now undergone extensive trials and is considered suitable for economic development. By a simple fermentation process it is claimed that the oil can be dissociated from the vegetable cells in a high state of purity and at low cost, and the process can be worked in the coconut groves themselves. The expense of drying coconuts into copra is eliminated, and the oil produced is said to be virtually water-white.

Tung Oil.—The Empire tung oil plantation scheme is still in the experimental stage, and the seeds used have been found satisfactory both as to quality and quantity of oil. The cake and meal which form the residue after extraction of the oil seem to be unpalatable to stock, even though they are rich in proteins and carbohydrates. Unless some outlet for these by-products is found the cost of production of the oil will be relatively high.

* An abstract of the paper describing the method appears in *Chemical Notes* of this number, p. 155.

Rubber. By *S. A. Brazier.*

For the first time since 1928 the world's consumption of rubber anticipated for the year will balance approximately the total production of rubber, but of course the plantations are still restricting their output on account of the unfavourable economic conditions. The development of Japan as a rubber-manufacturing country has become prominent during the year, and it is possible that it may displace France from the position of third largest consumer. Early in the year negotiations between English and Dutch planting interests were reported, and following these a steady improvement in price took place. From July to the end of the year the market price was steady round 4d. per lb. The continuance of low market prices for raw rubber has

encouraged the development of new uses for rubber, and in many cases it has been found possible to manufacture articles from rubber at prices directly competitive with the materials previously used, with perhaps additional advantages in physical characteristics and utility.

The use of sulphuric acid as a coagulant is still being studied, and it is concluded that if it were used in minimum amounts and removed from the rubber as completely as possible, no appreciable harmful effect would take place. The cost of sulphuric acid when used as a coagulant is estimated to be approximately one-half of that of formic acid and about one-third of that of acetic acid.

The reports on the rubber industry in Soviet Russia are still vague and untrustworthy, but there are indications that the consumption is increasing much more rapidly than the production. According to one report, the U.S.S.R. will have to import about 100,000 tons in the coming year, in spite of their efforts to develop the extraction of rubber from the tau-sagyz and kak-saugyiz plants. Considerable work is also being done on the production of synthetic rubber, and a report is current that several hundred tons of *butadiene* rubber have been made. The Du Pont Company in America are still busily engaged in researches on synthetic rubbers.

The use of latex as a bonding material has also been examined, and experiments have been carried out on the preparation and properties of sheets composed of latex and fibrous materials, together with the necessary vulcanising ingredients. The results of tests for bonding strength, impact strength, water absorption and inflammability of such sheets of bagasse, sisal and coconut fibre, show that generally speaking the physical properties were improved by the addition of latex.

Probably the most outstanding development of the year has been the introduction of a new thermoplastic moulding composition by the Goodyear Company of America. The new material "Plioform", is stated to be made from pure pale crêpe rubber by treating a solution of it with a special chemical reagent, with the formation of a pale granular product resembling granulated sugar. The material does not contain sulphur and does not require vulcanisation, and in consequence can be directly moulded to form transparent articles of a pale amber colour: or by addition of suitable pigments a coloured article of the usual type may be obtained. Its moulding characteristics are stated to be similar to those of cellulose acetate, and although it is soluble in petroleum solvents, it has good resistance to acids and alkalis, except nitric and concentrated sulphuric acids.

D. W. D.

COLLEGE SUGAR FACTORY CROP, 1934.

J. G. Davies, Dip. Agric. (I.C.T.A.), A.I.C.T.A.

The College Sugar Factory worked for 25 operating days between 13th March and 14th April. During this period it dealt with 658 tons of cane, and produced 67 tons of sugar, a ratio of 9.707 tons of cane per ton of 96 degrees test sugar. This is the best figure ever recorded except for the year 1930, when 9.12 tons of cane were used to make a ton of sugar.

The machinery worked satisfactorily, and no important breakdowns were recorded, except one of four hours when some slats had to be replaced in the cane-carrier. The total time lost was 4.37 per cent. of the grinding time. On Crop Day No. 6, all authentic existing records of the tons of cane ground during the ten-hour daily grinding period were broken—33.048 tons. The majority of the cane was of good quality and worked easily in the Boiling House. The last two days of the season were occupied in milling a Thin Cane experiment from the College Farm. Eight different varieties, each repeated four times, were milled separately, plot by plot, and the appropriate weights and analyses obtained in the factory. By this means the true relative merits of the varieties could be ascertained, and many important features from the factory point of view recorded, which would have otherwise been smothered if the plots had been sampled and then ground together.

Research was carried out into the possibility of using activated Bauxite as a clarifying agent. This agent yields an exceptionally clear juice (68 degrees Kopke Turbidimeter as against 25 to 30 degrees using ordinary lime and heat clarification) and shows indications of success for use on a factory scale. It is hoped to do further work next year with more elaborate equipment.

Six students took part in the working of the factory, and each was assigned to a definite post for different periods. This system enables each to obtain a thorough knowledge of the equipment, control, operation and organization.

The following figures are extracted from the Chemist's Final Report:

	1934.	1933.
Pol. % Cane	13.87	12.44
Fibre % Cane	14.23	13.63
Normal Juice: Brix ..	19.38	17.53
Pol. % ..	16.36	14.51
Purity ..	84.42	82.77
Final Molasses: Apparent Purity ..	37.87	38.85
Gravity Purity ..	44.04	—
Tons Cane ground ..	658.96	716.35
Tons Comm. Sugar ..	67.457	65.426
Tons Cane per ton Comm. Sugar ..	9.76	10.94
Pol. in Sugar % Pol. in Juice	79.86	78.98
Tons Cane per hour ..	3.01	2.76
Maceration % Fibre ..	131.89	100.06
Time lost % grinding time	4.37	2.47

Except for the Thin Cane Experiment mentioned above, the varieties ground were B.H. (10) 12 and P.O.J. 2878. Sugar was produced in the form of Yellow Crystals (98.10 degrees Pol.), "B" Sugar (96.27 degrees Pol.) and "C" Sugar (89.10 degrees Pol.). It was all disposed of locally.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Clarification of Juices from Newer Varieties in Hawaii.—*By W. L. McCleery.*

About the middle of the 1932 grinding season, the writer learned while at Paauhau that during a short run on P.O.J. 2878 cane difficulty had been experienced in clarification by slow settling. Although the P_2O_5 content of the juices was sufficiently high to indicate that good clarification might be expected, the settled juice was turbid and dark. In laboratory tests, it was not possible to secure reasonably clear settled juice at any reaction.

Mr. Cook therefore investigated the question using the juice from other canes, and he summarized his investigations as follows: the introduction of the newer varieties of cane, such as P.O.J. 2878, P.O.J. 36, Uba, U.D. and some others has greatly intensified the problem of clarification, the juices of which are found difficult to obtain in a sufficiently clear state. A large number of different materials which appeared to offer possibilities have been tested in this connexion such as phosphoric acid, sodium pectate and pectate pulp, tannic acid and tannin extracts, casein and other protein materials, sodium aluminate, zinc hydrosulphite and sulphur dioxide. Modifications of clarification procedure have been tried such as heating before liming, partial liming before heating, variations in reaction and temperature, a factory test at Waimanalo on hot versus cold imbibition, liming to considerably higher reactions and subsequent neutralization with phosphates or sulphur dioxide and various angles of sulphitation.

But all these juices can be cleared up if sufficient phosphoric acid is used, all requiring considerably more of this clarifier than older varieties and in many instances the quantity required is so great that the settlings cannot be handled with present settling capacity. Tests indicate faster settling and slightly less total volume if the juice is limed somewhat higher than at present and the phosphate added after liming. Addition of sufficient lime to raise the reaction to about pH 11.0 and then reducing the reaction with phosphoric produces a brilliantly clear, pale yellow juice. This requires about three times the present quantity of lime in addition to the phosphoric and produces a large volume of settlings. This is a treatment similar to one tried at Ewa some years ago.

Tannic acid and tannin extracts are complex materials and it has not been possible to establish all the controlling factors for their use. Excellent results have been obtained in some tests but their successful application appears to require some modification in procedure which we have not yet fully established. Sulphitation, properly controlled, gave clear, light cleared juice settling precipitate on all juices. The volume of settlings is about one-fifth greater than in present practice, but is less than the volume produced by the addition of phosphoric acid.

Sodium aluminate has not given promising results in laboratory tests, but Petree & Dorr Engineers, Inc. state that laboratory tests do not indicate the results secured in factory runs. Heating before liming was found to give variable results. There is marked improvement in some instances which appears most consistently in young plant cane from P.O.J. 2878. Improvement, however, is not consistent with the other newer varieties. Casein and other protein materials showed improvement in clarification, but successful application will require more study than appears warranted under present conditions.

Addition of zinc hydrosulphite produced a very clear juice and a rapid settling precipitate, but the volume of settlings is slightly greater than in present practice. Juices are very light coloured, but darken again on exposure or agitation with air.

Only three of the above expedients, therefore, offer definite possibilities under present conditions. It thus appears that no very simple expedient is going to be a cure-all, but it looks, at the present time, as though some form of sulphuring would be the best remedy.—(*Int. Sugar Jr.*, Vol. XXXVI, No. 424, pp. 166.)

* * *

Potash Fertilizer Tests in Java.—*E. Demandt.*

This summary of field tests with potash on cane in Java in the years 1908 to 1932 showed that on the whole potash and phosphate deficiency seem to go together. Among the various potash fertilizers used, muriate is given the preference. In general 3 quintals per hectare (270 lb. per acre.) have been found sufficient before, or shortly after, planting. Addition of organic material did not increase the effect of potash, nor did addition of lime.

On comparing the results of field experiments with potash content of the soil, it is observed that the increased yield obtainable by the use of potash regularly decreases as the potash (soluble in 2 per cent. citric acid) already in the soil increases. Results from the use of potash are most striking, on the one hand, when there is also a deficiency of nitrogen and phosphate, and on the other hand when there is an excess of these two elements. The good effects of potash are minimum when nitrogen and phosphate are in correct plant physiological balance.(—*International Sugar Journal.* Vol. XXXVI, No. 423, March, 1934, pp. 119.)

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE.

COLLEGE NEWS BULLETIN

JUNE, 1934.] [No. 1.

COLLEGE NEWS.

We offer our heartiest congratulations to the Principal on his Knighthood.

* * *

Mr. R. E. D. Baker has been reappointed on the College staff as Lecturer in Mycology for another year.

* * *

Mr. E. E. Cheesman, Professor of Botany and Genetics, sailed for England by s.s. *Costa Rica* on 14th May.

* * *

Mr. F. Hardy, Professor of Chemistry and Soil Science, will act as Principal during Sir Geoffrey Evans' absence in England.

* * *

Mr. D. D. Paterson, Reader in Agriculture, accompanied by Mrs. Paterson and children sailed for England by s.s. *Caribia* on 8th May.

* * *

Our thanks are due to Mr. C. Newman who has presented the College with a collection of photographs on the cultivation of rice in Malaya.

* * *

Sir Geoffrey Evans, Principal, accompanied by Lady Evans and Miss Evans will sail for England on 26th June by s.s. *Paluca*.

* * *

Mr. A. W. Paterson who acted as Professor of Economics during Professor Shephard's absence in the Gold Coast will return to England *via* Jamaica at the end of June.

* * *

Mr. A. M. Adamson, Lecturer in charge of the Department of Entomology and Mr. E. E. Pyke, Botanist to the Cacao Research Scheme will sail for England at the end of June.

* * *

Mr. H. E. Box has been seconded to the College from May, and will in future be attached to the Advisory Department for entomological work in the Northern Islands, with headquarters in St. Lucia.

* * *

Mr. G. A. Jones, Commissioner of Agriculture, and Mrs. Jones will sail for England by s.s. *Bayano* on the 12th June. Most of the Colonial Office scholars will return to England by the same opportunity.

Mr. A. Pickles, Entomologist to the Sugar Cane Investigation Committee, and Mrs. Pickles, recently returned from Brazil where they had many adventures and discovered certain new species of froghoppers.

* * *

Our thanks are due to Mr. R. D. Anstead, C.I.E., late Director of Agriculture, Madras, for presenting to the College Department of Agriculture a number of photographs dealing mainly with cattle and irrigation in Southern India.

* * *

Mr. G. R. Langdale who has been appointed Bursar arrived in Trinidad by s.s. *Cavina* on 18th February. Mr. Langdale who qualified as Chartered Accountant in 1931 was formerly on the Staff of Butchart, Carey, Dalman & Co.

* * *

We offer our best wishes and congratulations to Dr. E. Phillis, Assistant Physiologist to the Cotton Research Station on the occasion of his marriage to Miss Ann Glover which took place at St. Saviour's Church, Curepe, on 7th February.

* * *

Mr. P. E. Turner, Chemist to the Sugar-Cane Investigation Committee and Adviser in Sugar-Cane Experiments to the Commissioner of Agriculture and Mr. D. W. Duthie, Lecturer in Chemistry, sailed for England by s.s. *Coronado* on 29th May.

* * *

Mr. C. Y. Shephard, Professor of Economics, who has been seconded for a year to the Gold Coast, has recently made a five weeks' tour in Nigeria. He will return to the Gold Coast for a short time and then leave for a month's visit to Sierra Leone, returning to Trinidad in September.

* * *

Our thanks are due to Messrs. Lee, Howl & Co. Ltd., Tipton, for the presentation of a Compactum Pump for dealing with molasses in the Experimental Sugar Factory, and to Mr. Chas. Hayward for presenting on behalf of the Skeffo Ball Bearing Co., Lupton, a pulley in connection with the above pump.

The following members of the Staff sailed for England by s.s. *Cavina* on 14th May: Mr. J. G. Davies, Sugar Technologist; Mr. G. G. Gianetti, Registrar, Librarian and Editor of the College Journal, and Dr. C. W. Wardlaw, Pathologist to the Low Temperature Research Station.

* * *

Mr. F. Hardy, Professor of Chemistry and Soil Science, left for British Honduras on 25th April by air. He hopes to return on or about 10th June. Professor Hardy's services have been asked for by the Government of British Honduras to advise on the soils of the Stann Creek area, which it is proposed to develop for closer settlement.

* * *

An exhibit was recently staged at the Flower and Fruit Show in Port-of-Spain which showed the storage possibilities of both tomatoes and cauliflowers. The exhibits, which were in excellent condition, were grown by the College Department of Agriculture, while Dr. Wardlaw was responsible for looking after them in store, and selecting and packing them.

* * *

Dr. J. G. Myers who has been seconded to the staff of the College from the Imperial Institute of Entomology from the 1st April 1934, returned to Trinidad at the end of March. He has been on an extended tour of the Central Amazon area of Brazil on a hunt for insect parasites, and has been successful in introducing into British Guiana the Amazon Fly, which is a tachinid parasite on the small sugar cane borer.

* * *

Dr. H. R. Briton-Jones, Professor of Mycology and Bacteriology, sailed for New York by s.s. *Northern Prince* on 11th May, Dr. Briton-Jones will proceed from there to Washington, D.C. where he will pay an official visit to the Central Quarantine Station in order to make arrangements for close co-operation between the work of that station and that of the Plant Quarantine Station in Trinidad. This will include the exchange of plant material which has been passed through the respective stations. Dr. Briton-Jones after his visit to U.S.A. will proceed to England on leave of absence.

* * *

Mr. E. R. Leonard who has been appointed Plant Physiologist to the Low Temperature Research Station arrived in Trinidad by s.s. *Caraire* on 4th February. Mr. Leonard who was educated at Bishop Stortford College joined in 1923 the London Telegraph Training College and the British School of Wireless Telegraphy. After serving for two years as junior and later, senior wireless telegraph operator with Messrs. T. & J. Brocklebank, Liverpool, on voyages to India, America and Australia he entered, in 1927, the Imperial College of Science and Technology. In 1931 he obtained an Honours degree in Botany, specialising in his last year in plant physiology and pathology. Before coming to Trinidad Mr. Leonard worked for some time at the East Malling Research Station where he was engaged in carrying out investigations into the effect of stock on the carbohydrate production of apple leaves.

* * *

The College was visited by many distinguished people during the 1933-34 session. Early in February the College was honoured by a visit from their Highnesses the Princesses Helena Victoria and Marie Louise, and in March by Her Royal Highness Princess Alice and the Earl of Athlone. The College is yearly attracting more visitors and great interest in the progress of our scientific and academic work is being exhibited by foreign nations in addition to the component parts of the British Empire. Of the many foreign visitors of distinction may be mentioned His Excellency J. C. Kielstra the Governor of Surinam; Mr. J. Lanjoun, Conservator of the Herbarium Utrecht; His Excellency C. G. G. Anderberg, Ambassador to the Royal Swedish Legation, Mexico; His Excellency Dr. Suo K. Alfred Sze, the Chinese Ambassador to the United States of America; Governor General Olivièr, President of the Compagnie Transatlantique de Paris; M. Muller, Inspecteur Général of the Colonies, Paris. Of the numerous British visitors may be mentioned Dr. H. Gilbert Carter, Director of the University Gardens, Cambridge; Sir Alan Pim and Mr. S. E. Luke of the British Honduras Financial Commission; Sir Henry Gollan; Mr. E. J. Organ; Sir Lawrence and Lady Phillips; Sir A. R. Harris; Sir Bertram and Lady Jones; Dr. William A. Bone, F.R.S.; Professor J. L. Stocks of Manchester University and Dr. L. D. Stamp of the Land Utilization Survey of Britain; Dr. V. C. Dunlap and Mr. N. Sanderson of the United Fruit Company; Major the Hon. Edward Lascelles and Mrs. Lascelles; Sir Norman Lamont and Sir Edward and Lady Davson. His Excellency Sir Claud Hollis, the Governor of Trinidad and Tobago visited the College on several occasions during the year.

AGRICULTURAL EXCURSIONS.

THIS system of field days was further extended during the session, and 21 organized excursions were attended by the Post Graduates and Senior Diploma Students. Many of the localities visited were the same as last year but some new excursions were added, following on recent developments in the research work of the College and in the development in agricultural practice in the Island. There is reason to believe that these excursions are greatly valued by the students who find the experience most helpful as an amplification of their lecture programme. In all instances the College party received the most cordial welcome from the planters concerned. Every facility was placed at our disposal to make the visits instructive. For their help and for the hospitality offered the grateful thanks of the College are due. Special thanks are due to the Director of Agriculture and his staff for their help and arrangements in connection with the visits to Marper, River, and St. Augustine and the Government Stock Farm.

SIR JAMES CURRIE'S VISIT.

THE Chairman of the Governing Body visited Trinidad for three weeks in February, and with the exception of the last two days, when he accepted an invitation to stay with His Excellency the Governor, Sir Claud Hollis, resided at the College. Sir James, who is also the Director of the Empire Cotton Growing Corporation, naturally paid a good deal of attention to the Cotton Research Station at St. Augustine, in addition to the College. In his report on the latter Institution he mentioned that the objects of his visit were to contrast the conditions with those prevailing at the time of his previous visit in 1929, to form a first hand impression of the effects on the personnel of the College of the uncertainties of the last five years, and to form an impression of the progress of the research work in which the College is engaged. Sir James expressed his satisfaction at the progress that had been made during the last five years and was obviously delighted at the opportunity of renewing his acquaintance with the members of the Staff all of whom he met personally during the course of his visit. He was particularly impressed with the system of field excursions, two of which he was able to attend, and he had the pleasure of dining at the College Hostel and of meeting the Students.

His time was very fully occupied as meetings of the Advisory and Accounts Committee had been arranged and also a meeting of a Special Committee to consider the future of the Sugar Technology courses. Sir James left on 24th February by a Dutch boat, and returned to London *via* Surinam and Madeira.

MR. F. A. STOCKDALE'S VISIT.

THE Agricultural Adviser to the Secretary of State for the Colonies visited the College for a week in November and stayed with the Principal. He was on his way back to London after attending the West Indian Fruit and Vegetable Conference in Jamaica. Opportunity was taken to discuss the work of the College with the Principal and officers, the work of the Cacao Research scheme and of the Low Temperature Station being examined in some detail. At the time of his visit the inaugural meeting of the British West Indian Sea Island Cotton Association was held at the College, and he therefore had the opportunity of meeting the delegates from the Northern Islands and of discussing their problems. Mr. Stockdale dined at the College Hostel with the Colonial Office Scholars and also attended the showing of the film prepared by the Empire Marketing Board which depicts the various activities of the College. He also attended a meeting of the Central Plant Quarantine Committee and inspected the new Plant Quarantine Station which is now nearing completion.

EXAMINATION RESULTS.

Associateship.

The following students have been awarded the Associateship of the College :—

Mr. R. E. D. Baker, B.A. (Cantab.).
Mr. R. S. Ball, B.A. (Cantab.).
Mr. C. H. Burgess, B.SC. (Melbourne).
Mr. A. V. Coombs, Dip. Agric. (Wye).
Mr. R. P. Davidson, B.SC. Agric. (Edinburgh).
Mr. H. Gillman, B.SC. (Transvaal Univ.).
Mr. M. Halcrow, B.SC. (Edinburgh).
Mr. R. K. Kerkham, B.A., Dip. Agric. (Cantab.).
Mr. R. W. Kettlewell, B.SC. Agric. (Reading).
Mr. J. Lamb, B.SC. (London).
Mr. J. Marshall, B.SC. (London).
Mr. O. S. Milburn, B.A. (Oxon.).
Mr. J. Steele, N.D.A., N.D.D.
Mr. D. F. Stewart, B.SC. (St. Andrews).
Mr. J. O. Torto, B.SC. Agric. (California).
Mr. C. C. Webster, B.SC. Agric. (Wye).
Mr. D. G. Whitelaw, B.SC. (Reading).
Mr. G. V. Wickramasekera, (Ceylon).
Mr. E. Williams, B.SC. Agric. (Aberdeen).

COLLEGE SESSION, 1933-34.

Students in Residence.

First Year.

H. L. Ashing (Trinidad); A. Despointes (Martinique); A. C. Gomez (Trinidad); R. S. Junor (British Guiana); W. K. Mitchell (Jamaica); A. C. Robinson (British Guiana); M. A. H. Thomas (Trinidad); A. E. Wyatt (British Honduras).

Second Year.

S. Duncan (Antigua); M. S. Hassan (British Guiana); E. I. Hugh (British Guiana); H. M. James (England); C. Lai Fook (Trinidad); W. L. Lee (British Guiana); C. C. Seale (Barbados); A. C. Suarez (Colombia); A. E. Tai (Jamaica); A. V. Wan Ping (British Guiana); C. G. Wigley (St. Kitts); R. G. E. Yearwood (St. Kitts).

Third Year.

St. G. Cooper (St. Lucia); V. O. Ferrer (Trinidad); A. Garces (Colombia); A. D. Herbert (Barbados).

Third Year (Sugar Technology).

B. deB. Darwent (Trinidad); M. Moinuddin (India).

Colonial Office Students.

G. K. Argles, Dip. Hort. (Wye).
H. K. Ashby, B.A. Hons. (Cantab.).
J. Cook, B.Sc. Hons. (St. Andrews).
R. G. Fennah, B.A. Hons. (Cantab.).
M. W. Gibbon, B.A. Hons. (Dublin).
R. A. Hamilton, B.Sc. Hons. (Belfast).
J. R. Miller, B.Sc. Agric. (Edinburgh).
E. W. Momber, B.Sc. Agric. (Bristol).
R. F. A. L. Reed, B.Sc. (Lond.).
W. F. Steven, B.A. Hons. (Cantab.).
R. J. M. Swynnerton, B.A. Hons. (Cantab.).
J. D. Tallantire, B.Sc. Agric. (Leeds) N.D.A.
J. M. S. Usher-Wilson, B.S.A. (Ontario).

Refresher Course Students.

E. C. D. Green (New Guinea), Dip. Agric. (Hawkesbury).

W. R. C. Paul (Ceylon), M.A. (Cantab.), M.Sc. (Lond.), D.I.C., Dip. Agric. (Cantab.).

Special Students.

R. Depaz (Martinique); R. L. De Meillac (Martinique); H. B. Pidduck, N.D.A., N.D.D. Hons. (Dominica); H. P. Singh, B.Sc. (Lucknow). Mr. H. B. Pidduck attended a short refresher course lasting one term at the beginning of the session and Mr. Singh who specialised in Sugar Technology left in February.

OLD STUDENTS' CORNER.

A. Jones (1931-32), has been transferred from Saltpond to Asuansi, Gold Coast.

* * *

J. C. Muir (1926-27), is officer in charge, Division of Rural Economics, Accra, Gold Coast.

* * *

J. O. Torto (1932-33), and J. Cofie (1932-33) have been appointed Inspectors of Plant and Produce, Gold Coast.

* * *

C. H. Burgess (1932-33), has joined temporarily in Lincolnshire a Sugar Company which turns out 35,000 tons of sugar.

* * *

H. B. Stent (1930-31), has been appointed Agricultural Chemist to the Coffee Experimental Station, Moshi, and will be working with G. W. Lock (1930-31).

* * *

B. C. G. Charles (1931-32), is stationed at Karonga in the northern corner of Nyasaland. He has met Armstrong-Black (1930-31), S. T. Hoyle (1929-30), and R. Leach (1928-29).

* * *

J. T. Moon (1931-32), after holding a temporary post on a poultry farm in Hampshire, is now an Agricultural Officer in Kenya. He has been posted to a coastal district with C. O. Oates (1926-27).

* * *

R. S. Ball (1932-33), has been appointed Agricultural Officer in Kenya and is at present at the Plant Breeding Station, Njoro. He reports that he stayed for some time with C. A. Thorold (1928-29).

* * *

R. W. Kettlewell (1932-33), who was for some time attached to the Farm Economics Branch, Cambridge, and engaged on an agricultural economic survey of the Eastern Countries and then joined the staff of the Norfolk Agricultural Station, Sprowston, Norwich, has recently been appointed Agricultural Officer, Nyasaland. He expects to go there in July.

* * *

C. C. Webster (1932-33), has joined, as Research Assistant, the staff of the Tung Oil Estates Ltd., Hsum Hsai, Northern Shan States, Burma. This is situated at an altitude of 2,600 feet above sea level. The temperature rarely goes above 100 degrees and during cold weather falls to 40 degrees at night. The district is largely undeveloped. The estate has about 2,500 acres under tung oil (*A. fordii*), the nearest town being Maymyo.

Printed by the Government Printer.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Recovery of Vegetable Oils and Fats by a Bacterial Process.

In "Industrial and Engineering Chemistry" for February 1930, a paper by John W. Beckman gives in outline a process for recovering vegetable oils by a bacterial process. Renewed interest in this method has resulted from the fact that it has now passed the experimental stage and may do much to alter the present methods of vegetable oil production. The extraction of vegetable oils is mainly mechanical, although various methods of extraction with solvents have been tried with varying success. Taking copra as an example, the oil-containing cells are so small that even by passing the dried nut through a grinding mill only a limited amount of the oil is freed, and the cell walls are so tough that added troubles are encountered when the oil is expressed by mechanical means. Therefore various high-temperature treatments of the nut are necessary before the cell walls become brittle enough to crush under high pressure and so release the oil.

The cell walls are composed of cellulose, sugars, and proteins, and it is possible to remove the cell wall and liberate the oil in a state of purity by bacterial action. There is a very hardy and vigorous anaerobic and thermophilic bacterium, *Bacillus delbrueckia*, which is easy to obtain from brewer's malt and will attack sugars, changing them into lactic acid. In so doing it produces an enzyme which attacks proteins, breaking them down into water-soluble amino acids, but no change takes place in the oil itself. The temperature at which these agents prefer to work is 50°C., and this fact makes it possible to operate under conditions that are almost sterile, since most organisms are either killed at that heat or are inhibited in their activities. In the Beckman process a culture of this organism made from brewer's malt is mixed with disintegrated nuts, such as copra, together with a weighed amount of ground limestone and sufficient water to form a paste, and the resulting mixture is placed in an incubator at the desired temperature, with exclusion of air. Active growth takes place, carbon dioxide is given off by the action of the lactic acid on the limestone, and free oil begins to appear at the surface: at the same time the mixture becomes more and more liquid. After about six days the gas evolution comes to an end, and the oil can be removed by filtration through an Oliver continuous filter.

The quality of the oil depends largely upon the quality of the original copra. For example, a copra showing free fatty-acid content of 1.94 per cent., gave at the end of the fermentation 2.1 per cent., while a copra which contained oil with a free fatty-acid content of 10.6 per cent., gave at the end of fermentation 13.00 per cent. It is well known that the free fatty-acids act as catalysts and increase the rate of decomposition of the oil, and they are readily produced by the lipases formed by the action of moulds, but with properly covered incubators the temperature is such that the mould has no chance to grow, and the danger of oil decomposition due to lipases is practically negligible. The colour of the oil produced is superior to the average obtained by the usual pressure methods, and if the bacterial process is applied to fresh nuts, a water-white oil of exceptionally high quality is obtained.

The Beckman process is fully covered by United States and foreign patents.

* * *

Heavy Water.

Great interest has arisen in the recent discovery that water can no longer be regarded as a simple compound of two atoms of hydrogen united to one of oxygen, with molecular weight 18. A new hydrogen has come into prominence, an atom which is twice as heavy as ordinary hydrogen, and which has been named "diplogen" in England and "deuterium" in America, the chemical symbol being D. The new water has part or all of the "ordinary" hydrogen replaced by "heavy" hydrogen. Its density is about ten per cent. greater than ordinary water, hence its name "heavy water"; while its freezing point is 3.8° C. and its boiling point 101.42° C. Though in outward appearance this heavy water resembles ordinary water, yet its physical and chemical properties show marked differences. The vapour pressure varies markedly from the normal, the latent heat is considerably higher, the surface tension and specific inductive capacity are lower, and the viscosity is much greater.

Normal pure water contains heavy water in the proportion of about 1 to 6,000, but it is by no means certain that this is the proportion in natural waters. At present it is only the chemical and physical properties of artificially-prepared heavy water which are being studied, since only small quantities of the pure substance are obtainable, but it is suggested that the discovery of new water will be of great importance in animal and plant life. There has not yet been sufficient time to make more than a few preliminary experiments in this field, and then only on a small scale. Professor G. N. Lewis, of the University of California, who was the first to prepare nearly pure heavy water, found that the seeds of a certain tobacco plant did not germinate in pure heavy water, but did so when the concentration of heavy hydrogen (diplogen) was reduced to one-half of its original value. In experiments by other observers, well-defined physiological effects have been obtained for quite small concentrations of heavy hydrogen in water. If this new water has so great an influence on life processes, the foundations of plant and animal physiology are being threatened, but it is not known whether nature can produce water with a sufficient concentration of heavy hydrogen to affect plants and animals.—(*Nature*, Vol. CXXXIII, 1934, p. 481.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
29th March	4	10½	8	7½
5th April	4	6¾	8	6¾
12th April	4	6¾	8	6¾
19th April	4	10½	8	7½
26th April	4	10½	8	6
3rd May	4	6¾	8	6¾
10th May	4	6¾	8	6¾
(*11th May*, 1933)	5	4½	10	1½

After a slight recession in values the tone of the market is firmer and quotations on balance have shown an improvement. According to *C. Czarnikow, Ltd.*, the favourable turn of market trend is attributed primarily to a natural reaction from depressing conditions during previous weeks, and to the fact that buyers, at the reduced level of prices, have been encouraged to look to their forward requirements. Fairly considerable liquidation has also served to place the future's markets in a more healthy technical position while the prospects of early Government action in connexion with America's Sugar Control Bill are more hopeful. An outstanding development in sugar affairs in the United Kingdom has been an adjustment in the rates of preference granted to British Colonial producers. The object of the scheme is to balance Colonial supplies more evenly between the Canadian and United Kingdom markets and so terminate the present dislocation of trade between Canada and the West Indies.

* * *

COFFEE.—Business has been moderate except for good liquoring sorts. Latest quotations per cwt. include London cleaned Costa Rica, bold colony, from 94*s.* 6*d.* to 140*s.*; Kenya, bold grey-greenish and greenish from 89*s.* to 134*s.*; Santos, prompt, 47*s.*

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

28th March	5 3-16
4th April	5 5-16
11th April	5 19-32
18th April	5 3-4
25th April	5 15-16
2nd May	5 31-32
9th May	7 1-16
(*10th May*, 1933)	2 13-16

Since our last Report the Rubber market has been active, chiefly through the influence of contradictory restriction rumours. Improved consumption in America and the rest of the world, however, is also affecting market sentiment. Total consumption in America for the first three months of 1934 works out at 128,636 tons which compares with 60,170 tons in 1933.

COCOA.—On reports of increased consumption from American manufacturers, the terminal market has maintained its position. Against this, however, exchange regulations in Germany have made business slow. From cable advices, Accra is quoted at 24*s.*; Arriba at 42*s.*; whilst locally $6.60 a fanega is paid for Plantation Cocoa.—(*By courtesy of The Cocoa Planters' Association of Trinidad Limited.*)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
29th March	6.35	8.74
6th April	6.40	8.75
13th April	6.35	8.61
20th April	6.18	8.19
27th April	5.97	—
4th May	5.97	—
11th May	6.13	—
(*12th May*, 1933)	6.19	8.19

Business in American has been quieter with quotations generally lower. Business in West Indian Sea Island has been confined to a few stains at from 7¾*d.* to 9*d.*. The leading spinners of white cotton have bought so freely lately that only a retail enquiry is expected for some time to come.

* * *

COPRA is quiet and West Indian f.m.s. is 7*s.* 6*d.* per ton lower at £8 15*s.* c.i.f. London.—(*West India Committee Circular*, 12th April.)

* * *

BANANAS.—A fair business has been done in Jamaicas, and the wholesale prices of both the Jamaica Producers and Elders & Fyffes are unchanged at £19 5*s.* per ton delivered London and £19 nearest station Provinces. Brazilians are in good demand at the unaltered price of £17 10*s.* delivered nearest station.—(*West India Committee Circular*, 12th April.)

* * *

GRAPEFRUIT.—The average prices ruling in Covent Garden for the week ended 7th April, according to count and condition were :—

	s.	*d.*
Jamaica	9	6 to 12 0
Palestine	9	0 to 14 6
Trinidad	9	0 to 16 0
Isle of Pines	8	3 to 11 0
California	11	0 to 13 0
Florida	9	9 to 15 6
Puerto Rico	10	6 to 12 0

—(*West India Committee Circular* 12th April.)